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# THESIS

A DESCRIPTION OF THE GENERAL CIRCULATION IN THE NORTH ATLANTIC OCEAN BASED ON MASS TRANSPORT VALUES DERIVED FROM IGY (1957-1958) TEMPERATURE AND SALINITY DATA

by

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(20. ABSTRACT Continued)

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Comparisons are made with the actual current observations available for localized regions and with earlier calculations of this circulation.

There is considerable evidence that a geostrophically-calculated description of the North Atlantic general circulation, based on a level of no motion that lies near 1100m, compares favorably when compared to past transport estimates, past descriptions of the general circulation, and direct current measurements while having the singular advantage of maintaining the necessary continuity of total mass transport in the ocean.

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# A Description of the General Circulation in the North Atlantic Ocean Based on Mass Transport Values Derived from IGY (1957-1958) Temperature and Salinity Data

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Submitted in partial fulfillment of the
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## ABSTRACT

Using the results from geostrophic current calculations made along latitude sections sampled during the International Geophysical Year (IGY; 1957-58), the circulation above and below the level of no motion is evaluated quantitatively for the region between 8°N and 40°N in the Atlantic Ocean. The geostrophic current calculations have been based on a reference level of no motion established by a requirement of mass and salt flux continuity across each of the latitude sections (40°N, 36°N, 32°N, 24°N, 16°N, and 8°N). Current calculations extend to near bottom across each section.

Comparisons are made with the actual current observations available for localized regions and with earlier calculations of this circulation.

There is considerable evidence that a geostrophically-calculated description of the North Atlantic general circulation, based on a level of no motion that lies near 1100m, compares favorably when compared to past transport estimates, past descriptions of the general circulation, and direct current measurements while having the singular advantage of maintaining the necessary continuity of total mass transport in the ocean.

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# I. INTRODUCTION

The heat budget of the earth is characterized by a net gain of heat at the equatorial region and a net loss of heat at the poles. Since these areas are not becoming progressively warmer or colder it is apparent that excess heat is being transported by various mechanisms from the equator poleward. Studies of the oceanic contribution to this transfer of heat have been made in recent years (Jung, 1955; Budyko, 1956; Sverdrup, 1957; Bryan, 1962; Sellers, 1965; Vander Haar & Oort, 1973). In his 1974 Master's Thesis Greeson developed a computer program capable of determining heat flux from hydrographic data across an extensive ocean section. By varying the level of no motion along an ocean section, in this case an ocean cross section along a near constant latitude, it is possible to determine values of heat flux where the requirement is met that the net fluxes of mass and of salt are zero. Greeson examined a single latitude section, 40°N, for mass, salt, and heat flux. By applying his computer program to the series of quasisynoptic latitude sections of hydrographic data from the International Geophysical Year (IGY; 1957-58) it is possible to examine the general circulation of the North Atlantic in terms of mass conservation across individual sections and mass continuity between separate sections. The extent to which this circulation picture correlates

with known circulation features, directly-measured currents, and other measured and calculated estimates of transport will provide an indication of the validity of this particular study and of associated studies involving salt flux and heat flux in the North Atlantic using the same data and method.

The most distinguishing feature of this approach is the location of the level of no motion. Except in shallow areas where it is located on or near the bottom, it is located between 900 and 1300 meters with the vast majority of the values (93%) falling within the zone of 1000m to 1100m. South of the 40°N section, where most values fall between 1100m and 1200m, 96% fall between 1000m and 1100m. Tests that changed the level of no motion by 50 or 100 meters on either side of the selected level showed results that do not meet the mass or salt continuity requirements. It was clear that greater departures would bring greater discrepancies. Sverdrup et al. (1942) and Bowden (1954) advocated the application of continuity considerations to selection of the level of no motion as ideal provided that sufficient data existed. In describing the continuity approach, Bowden says "... For example, the flow of water at various bands of latitude in the North Atlantic must be such that, on the average, the net flow from surface to bottom is zero since no appreciable amount of water can be accumulated or removed from the North Atlantic which is practically

closed at the northern end." It should also be clear that no mass or salt can be accumulated within such an ocean vertical cross section, nor can a net depletion occur.

As will be shown, there is substantial evidence both in the literature and in the results of this study to indicate that the elusive level of no motion may be in the vicinity of 1100 meters in the open ocean, even where strong currents exist.

# II. BACKGROUND

## A. LEVEL OF NO MOTION

The question of reliability of dynamic calculations in general is inseparable from that of the determination of a suitable reference surface, or level of no motion, by which to transform relative into absolute velocity. Greeson (1974) provided an in-depth discussion of the various methods which have been used for determining the level of no motion. Using the method first advocated by Sverdrup et al. (1942) which requires selection of a level of no motion such that the net mass transport across an ocean section is zero, Greeson arrived at a level of no motion of 1100-1300m for the 40°N IGY ocean section. Through the use of a computer, he was simultaneously able to meet a requirement for a net salt flux of zero across the section. Application of Greeson's computer program to the IGY data for 36°N, 32°N, 24°N, 16°N, and 8°N yielded a similar result (1000-1100m) for the level of no motion in these sections.

A literature survey on this subject reveals conflicting evidence as to the location of this reference level. Virtually all of the recent discussion on this subject centers around its location in the region of the Gulf Stream.

One who subscribes to the idea of a level of no motion in the vicinity of 1100m can find solace even among the results of those who advocate a much deeper location.

Swallow and Worthington (1961) made estimates of the level of no motion beneath the Gulf Stream through the use of neutrally buoyant floats bracketed by hydrographic stations. They concluded that the level of no motion is located at about 1900m in the deep water off the Blake Plateau. However, some of their results can be interpreted as supporting a shallower location for the reference level.

When one of their hydrographic sections successfully crossed the path of a float, one direct measurement was available and, on the basis of this measurement, the level of no motion between the bracketing stations was computed. Using this method they calculated levels of no motion of 2070m, 1950m, 2150m, 1640m, and 1820m as they crossed and recrossed the paths of three of their floats which they identify as B, D, and G. However, in describing their research on 27-29 March they wrote,

"Three pairs of stations (5533-5534, 5535-5538, and 5536-5537) were made across the paths of floats H and I but unless the level of no motion lay much shallower than 1500m the spacing of these stations was too wide to measure the true slopes of the isobaric surfaces and in consequence the computed currents are far slower than the observed.....

"On the morning of 29 March, ATLANTIS left the working area in order to start the final oceanographic section. This section, it had been agreed, was to include the entire

Florida Current as well as the deep undercurrent. The first station, 5547 was at 33°01'N,73°30'W about 220km east of the working area. The stations consisted of two series except on the shelf and while crossing the tracks of floats J and K when only one series was made. Again, it seems the oceanographic measurements were not adequate; only half the velocity of these floats could be accounted for by the dynamic calculations unless the level of no motion were raised to 1000m. While this could possibly have been the case, it seems more sensible to assume that the true slopes of the isobaric surfaces were missed by ATLANTIS and that the level of no motion lay at some greater depth......

"On the basis of the existing stations, no satisfactory level of no motion could be obtained by using the deep floats H-K."

The four rejected floats which indicated a shallower level of no motion actually outnumber the floats used in concluding that the level lay at 1900m. They also mention that difficulties are encountered in extending the use of their 1900m reference surface to larger areas.

Rowe and Menzies (1968) conducted bottom photography and hydrographic sampling along the continental slope and rise beneath the Gulf Stream between 36°-32°N and 77°-71°W. From the temperature and salinity gradients that they found and from dune-shaped ripple marks in their photographs they concluded that the Gulf Stream may have extended to

the bottom during the month of June. But for data and photographs taken during March and November they write, "... on the contrary, the Gulf Stream did not impinge on the bottom where the samples were taken. Between approximately 800m and 1000m across the transect a zone of no motion impinged on the bottom." This was evident in the lack of current indications from hydrographic stations near 1000m. Also, the undisturbed animal tracks and trails in the photographs indicated that no current existed.

Rowe and Menzies did find photographic evidence of a southward-flowing bottom current from about 1100m on the steep slope to about 5100m on the lower rise.

Saunders (1971) conducted an investigation of Gulf Stream meanders and eddy formation. He conducted 1500 STD lowerings at 70°30'W between 39°45'N and 39°30'N and made geostrophic computations based on an assumed level of no motion of 1000db which gave him surface current results closely comparable with direct current measurements that he made at the same time. He also concluded from his study that meanders and eddy circulations are confined to the upper 1000m.

There is other evidence, which cannot be ignored, that the Gulf Stream extends to the bottom. Warren and Volkman (1968), using neutrally buoyant floats and hydrographic data, got results indicating that at 2500m the current was in approximately the direction of the surface Gulf Stream and of sufficient velocity to imply a net flow at the bottom (4200m) in the same general direction as the surface current.

Knauss (1965) tracked a Swallow float at 2000m in the same general direction as the surface Gulf Stream for a period of 24 hours. He also made a 17-hour direct current measurement at the bottom and got the same result thus concluding that, "at least during this time and at this place the Gulf Stream extended all the way to the bottom." His measurements were made in the vicinity of 36°04'N, 73°13'W.

Schmitz, Robinson, and Fuglister (1970) made current measurements 200m above the bottom between 36°N and 39°N at 70°W over a period of 60 days and found that north-south variations in the path of the Gulf Stream and in near bottom currents were essentially in the same direction at nearby times.

Using deep moored current meters and hydrographic data, Richardson (1974) concluded that off Cape Hatteras the Gulf Stream did not reach the bottom but extended to about 2000m beneath its core.

The conclusion the author draws from the foregoing is that the location of the level of no motion is still an open question. The uncertainties involved and the supportive evidence available provide sufficient license for one to proceed with a study such as the present one which is based on the selection of a level of no motion near 1100m. It should also be added that it is not the intent of this study to establish that the level of no motion can lie only near this depth but instead to establish that, for the

latitude sections used in this study, the general circulation is well represented by such a selection while mass and salt continuity are preserved.

## B. HYDROGRAPHIC DATA

There is a dilemma facing an oceanographer who attempts to examine the complex ocean circulation. He can move about making a single set of observations over a large area and assume that time variations during the measurement program are sufficiently small that he can treat his observations as having been made simultaneously; or he can stay in one location and make a long time series. Although such a program can provide a good measure of local variability, it is often difficult to infer much about the broader question of oceanic circulation (Richardson and Knauss, 1971).

The former alternative along with its primary assumption was employed for this study.

The hydrographic data used for this study are taken from the data compiled during the IGY (1957-1958) as published by Fuglister in 1960. Temperature, salinity, and depth data were taken for oceanic transects at various latitudes. The data extend to near shore and near bottom. This provides the most nearly synoptic comprehensive collection of such data for this large ocean area taken to date. Table I shows the seasons and years that the data used in this study were collected.

Figure 1 illustrates the tracks along which the data were taken. Three things should be noted here concerning the data.

First, although the majority of the data was collected in 1957, portions of the tracks were taken as early as 1954 and as late as 1959. In practice, these are all assumed to be IGY data (1957-1958).

Second, the 32°N section is the least synoptic of the individual sections in that it contains data from three different years and two different seasons. It also contains a leg at its western end which runs from northwest to southeast instead of east-west and it actually crosses the 36°N section near its western endpoint.

Lastly, at 27°N a short section is added in order to complete and supplement the 24°N section by including the important influence of the strong Florida Current. The 27°N data are two years and several months earlier than that at 24°N.

The influence of the peripheral areas along the margins and at depths not covered by the data sections is dealt with in Section IV.

Table I

Hydrographic Data; Year of Record and Location

| LAT | DATE(S) | ENDPOINTS WEST | ENDPOINTS EAST |
|---|---|---|---|
| 40°N | 2 Oct 57-22 Oct 57 | 40°15'N, 68°25'W | 40°14'N, 9°33'W |
| 36°N | 19 Apr 59-12 May 59 | 36°16'N, 74°48'W | 36°26'N, 6°30'W |
| 32°N | 9 Jun 55-14 Jun 55 | 36°44'N, 74°44'W | 33°01'N, 65°57'W |
| " | 22 Apr 57 | 32°15'N, 64°22'W | —— |
| " | 11 Nov 54-16 Nov 54 | 32°00'N, 63°03'W | 32°01'N, 50°44'W |
| " | 24 Nov 57- 7 Dec 57 | 32°14'N, 50°25'W | 32°16'N, 9°44'W |
| 27°N | 27 Jun 55-28 Jun 55 | 27°23'N, 79°58'W | 27°24'N, 79°08'W |
| 24°N | 6 Oct 57-28 Oct 57 | 24°31'N, 75°28'W | 24°30'N, 16°20'W |
| 16°N | 13 Nov 57-29 Nov 57 | 16°16'N, 61°00'W | 16°15'N, 16°48'W |
| 8°N | 6 May 57-21 May 57 | 8°16'N, 57°42'W | 8°14'N, 14°24'W |

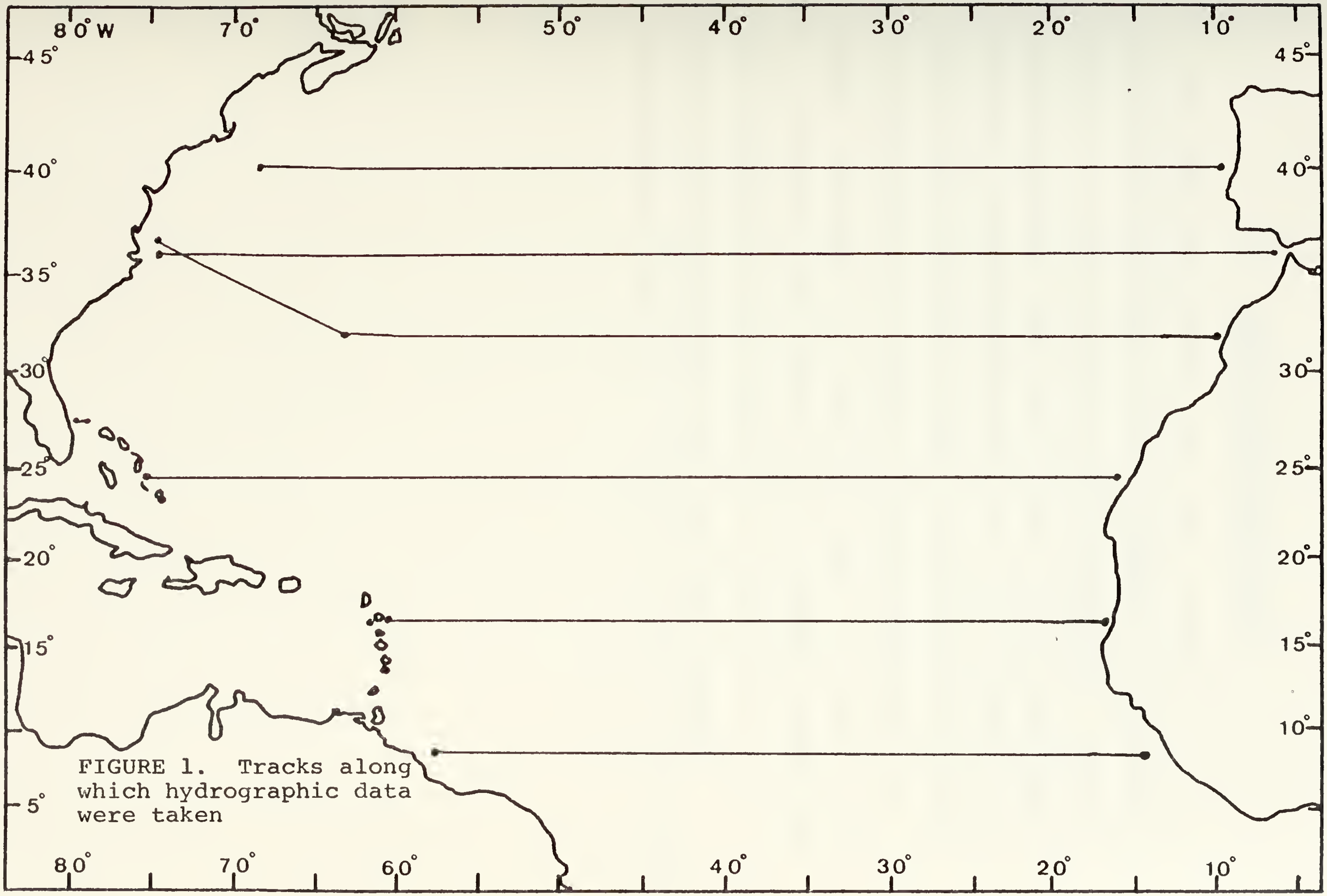



FIGURE 1. Tracks along which hydrographic data were taken

## III. OBJECTIVES OF THE STUDY

The objectives of this study were threefold: (1) to describe quantitatively the mass transport in the North Atlantic at several latitude sections based on a level of no motion chosen so that the net mass and salt transports across each section approximate zero; (2) to examine the longitudinal continuity of mass transport above and below the chosen level of no motion and draw conclusions concerning the general circulation in these two layers; and (3) to correlate the resulting mass transport values with other estimates of this circulation through the use of direct current measurement data, past mass transport measurements and estimates, and past circulation descriptions.

# IV. PROCEDURES

## A. GEOSTROPHIC DATA

Using the computer program developed by Greeson (1974), levels of no motion were chosen between stations along the IGY Data latitude bands of 40°, 36°, 32°, 24°, 16°, and 8°N so as to require a net balance of mass and salt transports or flux across each band. The computer program output contains a wealth of physical and dynamical information but for this study only the computations for the distributions of mass transport with depth and geostrophic current velocity with depth were used.

The mass transport is computed for rectangular vertical cross sectional areas which are equal in width to the station spacing and vary in depth from 50-meter increments in the upper layers to 250 meters in the deeper layers.

The total mass transport above and below the chosen level of no motion was summed for each pair of stations. All summations were made accurate to five decimal places.

To evaluate the influence of that portion of the vertical cross sectional area of the ocean not covered by the geostrophic data, a study was made of the periphery of each section shoreward of the most nearshore station and of the area remaining below the deepest computed mass transport value for each pair of stations.

Using soundings from navigational charts for the areas in question, a vertical cross section was calculated for the coastal endpoints of each cross section of latitude.

For the area below that involved in geostrophic computations, the actual depths for each pair of stations taken from Fuglister (1960) were first averaged and multiplied by the station spacing. Then the average depth between the stations as used by the computer was multiplied by the station spacing and subtracted from the total thus determining the area which had not been covered. As a further step towards accuracy when averaging the actual depths, a visual check was made of the bottom profile illustrations in Fuglister and corrective allowances were made when irregular terrain between stations was significant enough to affect the average depth. The results of this evaluation of the periphery are shown in Table II . The net result was that the nearshore contribution to error was found to be negligible, accounting for far less than even 1 percent of the total area. The bottom contribution was more significant and amounted to ≃ 10% of the total area, varying slightly among the latitude sections.

This "loss" of the bottom 10% was attributable to three factors:

(1) in many cases the original data were only taken to near bottom;

(2) the geostrophic calculations can extend only as deep as the shallower measurement between two stations; and

TABLE II

Peripheral Areas

| | AREAS IN $KM^2$ | | | | | PERCENTAGES | | | |
|---|---|---|---|---|---|---|---|---|---|
| LAT | SIDES | | | | | | | | |
| | WEST | EAST | COMPUTER | BOTTOM | TOTAL | COMP./COMP. | COMP./(COMP. + SIDES) | COMP./(COMP. + BOTTOM) | COMP./(COMP. + SIDES + BOTT.) |
| 40°N | 33 | 7 | 18,917 | 2,137 | 21,094 | 100% | 99.8% | 89.9% | 89.7% |
| 36°N | 6 | 1 | 23,071 | 1,902 | 24,980 | 100% | 99.9% | 92.4% | 92.4% |
| 32°N | 6 | 3 | 23,591 | 2,830 | 26,430 | 100% | 99.9% | 89.3% | 89.3% |
| 27°N | 0.5 | - | 28 | 8 | 36.5 | 100% | 98.4% | 77.3% | 76.3% |
| 24°N | - | 6 | 27,284 | 2,797 | 30,087 | 100% | 99.9% | 90.7% | 90.7% |
| 27°N+24°N | 0.5 | 6 | 27,312 | 2,806 | 30,125 | 100% | 99.9% | 90.7% | 90.7% |
| 16°N | 0 | 2 | 17,384 | 3,207 | 20,593 | 100% | 99.9% | 84.4% | 84.4% |
| 8°N | 2 | 5 | 17,630 | 2,319 | 19,956 | 100% | 99.9% | 88.4% | 88.4% |

(3) the computer program only calculated values for the deepest whole 250-meter increment for which it had data.

While it might be possible to modify a computer program to use smaller increments near the bottom, it would appear that the first two causes are permanent ones which will always make a 100% cross sectional area unattainable in studies of this kind.

Above and below the level of no motion, geostrophic calculations at each latitude were then combined into 5° increments of longitude to be displayed as a mass transport grid for the North Atlantic. 10°, 15°, 20°, and actual station spacing increments were all examined to determine which display was the most workable and valuable representation for attempting to describe the general circulation based on continuity of mass. Using station spacing was unsuitable because of the very tight spacing in the near-shore areas and the irregular spacing throughout the actual data. 10°, 15°, and 20° increments were progressively less useful in describing the circulation in that significant flows were blended out (however, these three types of longitude increments are included along with 5° in the results for comparison).

## B. CURRENT DATA

The collection of data on direct measurements of currents in the region under study was approached in the following manner.

The intent was to obtain the largest number of separate measurements possible so as to be able to correlate the measured and calculated current velocities in several different ways which will be described in Section V.

The first step was the initiation of a computer search via the Defense Documentation Center of Alexandria, Virginia, for all unclassified reports on file dealing with North Atlantic Ocean currents since 1955. This produced a listing of some 145 reports of which, after their abstracts were reviewed, 62 were screened and recorded when found to be applicable.

A further step was a survey of the non-technical literature since 1955 using the Reader's Guide to Periodical Literature and searching under the headings "Ocean Currents" and "Gulf Stream."

This search was of little help because what information was available was for the most part insufficiently detailed with regard to depth, location, and duration of current measurement.

The journals Deep-Sea Research, Journal of Marine Research, and Journal of Geophysical Research were screened from 1953, 1937, and 1949 to the present, respectively. Oceanology was examined from 1965 to 1969 as was Tellus from 1949 to 1965.

In addition, 23 miscellaneous technical and cruise reports were reviewed.

When compiling the data, a record was made of the month and year it was taken, the latitude and longitude, the depth, the duration of the measurement, and the velocity.

Current data were discovered in many formats. The following parameters were used in standardizing the tabulation:

(1) Latitude and longitude were rounded to the nearest whole minute in those cases where its accuracy had been recorded to include seconds.

(2) When neutrally buoyant floats or drogue measurements were made and a start and finish position were available, the mean latitude and mean longitude between the two points was recorded as the position.

(3) When a measurement spanned more than one month, all the months involved were recorded and given equal weight in the temporal correlation.

(4) The depth was recorded in meters and in those cases where the depth was presented as a central value plus or minus some error tolerance, the central value was taken.

(5) The duration was rounded to the nearest whole day above zero.

(6) The direction and speed were found to be the most diverse in format. The direction was given to varying degrees of precision ranging from degrees true plus or minus an error tolerance to 16 point compass headings (i.e., NNE) and even to just "southerly." Those in which

tolerances were given were recorded as the central value. Those less precise than compass headings were rejected.

Speed was presented in cm/sec, mm/sec, and knots. All values were converted to cm/sec. Speeds for which central mean values plus or minus an error tolerance were given were recorded as the central value. In some instances mean currents were expressed as a range of values (i.e., 9-12 cm/sec). When this occurred, they were recorded as a range. Since the values were already expressed as a mean, further averaging of the endpoints of the range in order to obtain a single value was not considered justifiable. For converting knots to cm/sec the conversion factors used were:

1 nautical mile = 1852 meters

1 knot = 51.44 cm/sec

Due to their questionable accuracy, no ship-drift current measurements were used.

The final step in tabulating the current data was to take the meridional component of the velocity vector for comparison with the computed geostrophic values. Special treatment was given to data in the western portion of the 32°N section to account for its comparison with currents calculated across the section oriented at a significant angle to the latitude parallels.

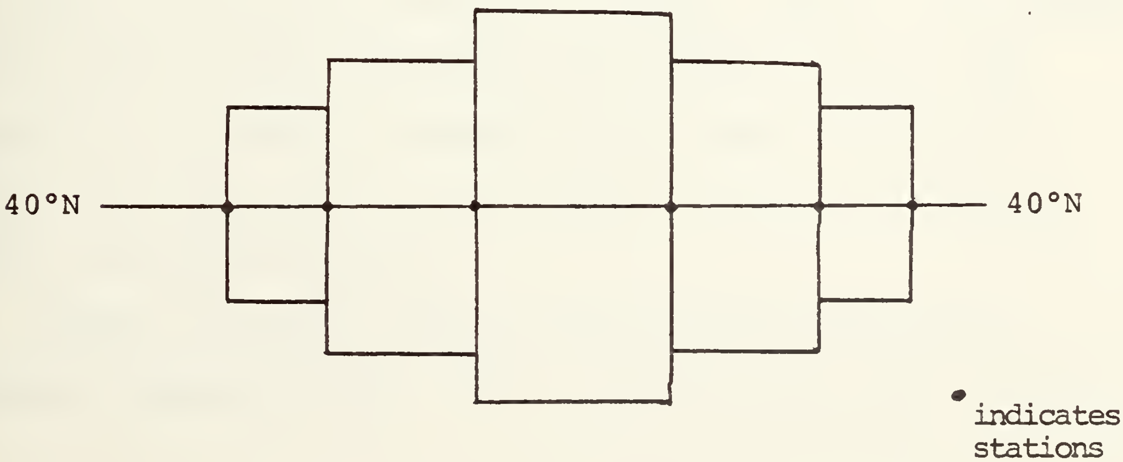
At this point, there were 523 separate direct current measurements tabulated and the time had come to begin to apply some elimination criteria to refine the data to the point where each measurement could be considered of equal weight with the others when making the comparison to the geostrophic values.

The first step was the outright elimination of those measurements which lay outside of the lateral and vertical bounds of the geostrophic computations and those which had been characterized as being of only "fair" reliability. This "fair" reliability applied to data from one source only, NAVOCEANO Pub. 700 (1965), a tides and currents atlas which was unique in that it listed the month but not the year that the data were taken and did not list the duration of the measurements. Data in this source which were characterized as being of "good" reliability were retained except that they too were discarded when the comparisons involving time were made.

The second step was to combine measurements which were so close in time, space, and velocity as to be considered as one value. This applied in a few cases, such as when currents had been measured at 4, 10, 16 meter depths in one location on one occasion. The smallest depth increment in the geostrophic calculations is 50m so these values were combined, provided that they were sufficiently similar to all meet the same comparison criteria to be discussed in Section V.

The final step, which eliminated by far the greatest number of data points, was the establishment of a longitudinal distance cutoff to be measured from the latitudinal tracks along which the IGY data were taken. Station spacing was as small as 9nmi in some places near the coasts and as much as 108nmi in the open sea while latitude band separation was 240nmi in the northern 3 bands and 480nmi in the southern 3. It was necessary to choose a reasonable distance over which the calculated meridional mass transport values and current velocities could be considered constant and establish that area as the limit for comparison of direct current measurements.

The procedure followed was to draw a square above and a square below each pair of stations with the sides of both squares equal to the distance between the two stations. Data within a square were compared to geostrophic calculations along the latitude line. The principle is illustrated below:



These three procedures reduced the number of usable direct current measurements within the region to 110. These directly measured values then were compared to the nearest computed values. Favorable and unfavorable comparisons were examined with respect to depth, season, time elapsed since the IGY, and in general.

## C. PROBLEM AREAS

The three means of checking the validity of this study are: comparison with previously calculated mass transport figures, success in describing the general circulation while maintaining mass continuity, and the degree of correlation between computed and directly-measured currents.

The correlation of currents presents the most awesome problem. Simultaneous direct current measurement and station taking is the ideal circumstance, though it is rarely realized, and certainly not on a synoptic ocean-wide scale. To obtain sufficient current data to make a comparison, it is necessary to make use of all the measurements that are available; the spread of the data in time and space is such that seasonal changes, eddies, and meanders would seem to make any correlation unlikely, unless one trusts in an overall constancy in the ocean circulation which would be sufficient to blend out transient effects, given enough data points.

Another problem is that of dealing with meridional current components only. This is both an aid and a hindrance

when making comparisons. As long as a measured current falls within the desired direction semi-circle, northern or southern, its chances of agreement with a computed meridional current component are improved because a wide range of velocities at various headings can have the same north (or south) component. However, when the actual current flow is nearly east or west, a slight disagreement in direction can cause the flow to fall in the opposite semi-circle from the geostrophic flow and appear to be in complete disagreement.

The Gulf Stream axis provides a means to convert the northward component of calculated mass transport to total mass transport along the western edge of the Atlantic and thus to make comparisons to other transport estimates. The absence of any well-defined axes of flow in the remainder of the region unfortunately made similar comparisons impossible outside of this one area.

The literature search for current data failed to turn up a single directly-measured current along the 8°N latitude section. With no current data for comparison, the validity of the section's mass transport values was open to question. Because the other five sections did compare favorably with direct current measurements, as will be shown, and because the same procedure was used in computing all six sections, the 8°N section was included in the overall mass transport picture.

# V. RESULTS

## A. GEOSTROPHIC CALCULATIONS

Table III shows the net mass transport across each latitude band above and below the level of no motion:

TABLE III

Net Mass Transports

| LAT | 40°N | 36°N | 32°N | 24°N | 16°N | 8°N |
|---|---|---|---|---|---|---|
| Above LNM | 19 | 18 | 17 | -2 | -1 | -1 |
| Below LNM | -19 | -18 | -17 | 2 | 2 | 1 |
| NET | 0 | 0 | 0 | 0 | 1* | 0 |

ALL UNITS x $10^{12}$ gm/sec

* Results from rounding the summary values

While the real value of the mass transport calculations lies in smaller scale displays, this table does illustrate some gross features of the North Atlantic.

The most striking feature of this table is the apparent discontinuity between the three northern sections, 40°, 36°, and 32° and the three southern sections 24°, 16° and 8°.

There are two possible explanations for this. First, the most dominant feature of the North Atlantic above 25°N is the Gulf Stream region which, in general terms, is characterized by strong northward flow in the upper layers and by counterflows at depth. This single feature overshadows

the weaker transports in the regions farther east and appears as strong flow above and below the level of no motion when compared to the sections south of 25°N where the Gulf Stream is not present. Secondly, the general circulation in the North Atlantic in the broadest sense is a clockwise gyre which is predominantly a westward latitudinal flow to the south of 25°N becoming predominantly meridional, especially near land, north of 25°N. Since only meridional components are taken, the flow based on them appears markedly weaker in the southern sections.

It also appears that there is shallow divergence and deep convergence between 24°N and 32°N.

The more precise breakdown of the mass transport values above and below the level of no motion is shown in Figures 2 through 9 in 5°, 10°, 15°, and 20° increments. The 5° increment display is selected to describe the general circulation because it provides the best blending of the flow without obscuring important features.

All mass transport values are expressed in whole numbers whose units are $10^{12}$ gm/sec. In arriving at these figures, accuracy to five decimal places was maintained during all summing and interpolating until the final rounding off for display.

The western Atlantic, and the Gulf Stream in particular, is the only area where sufficient past research has been done to provide a good basis for comparison of transport

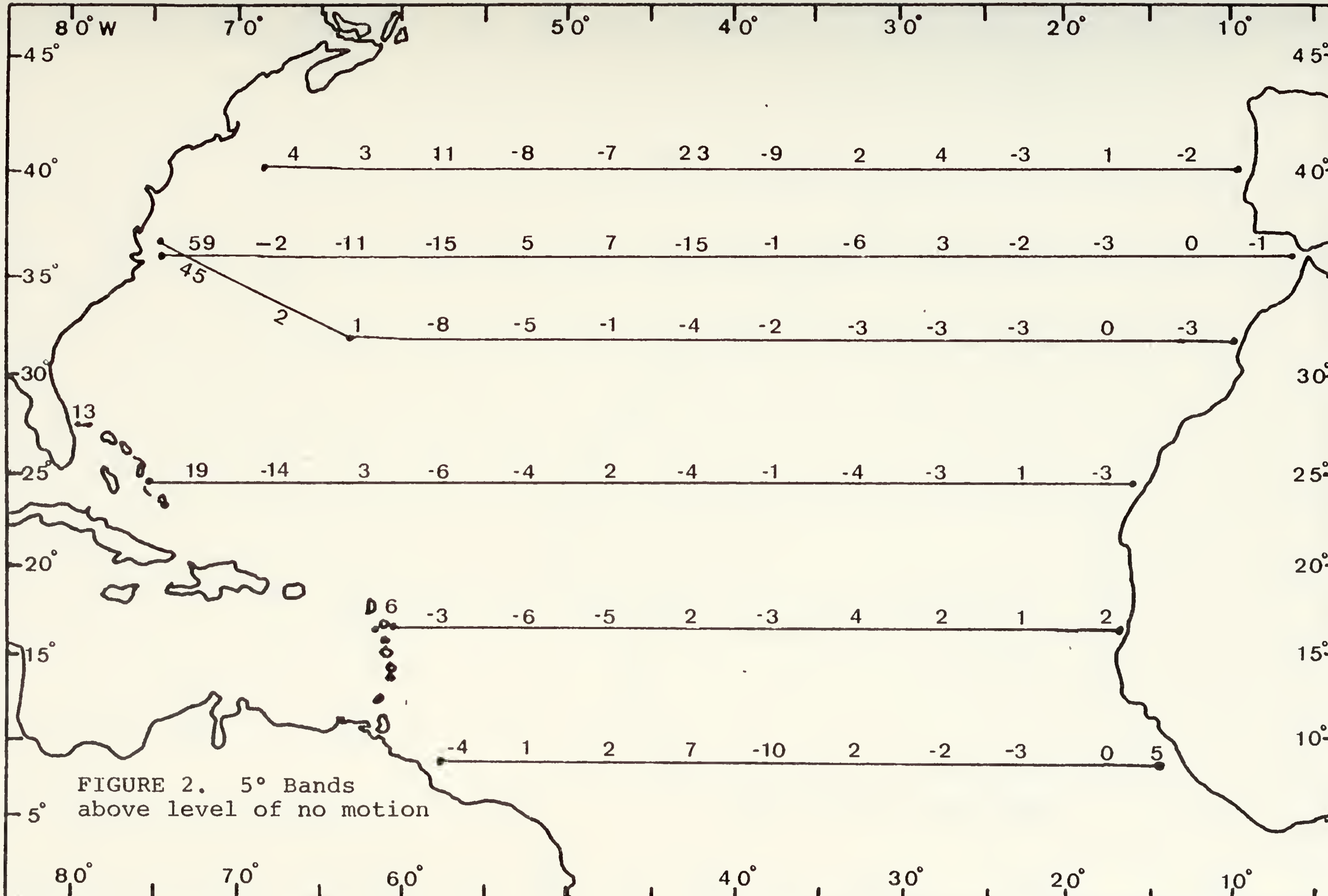



FIGURE 2. 5° Bands above level of no motion

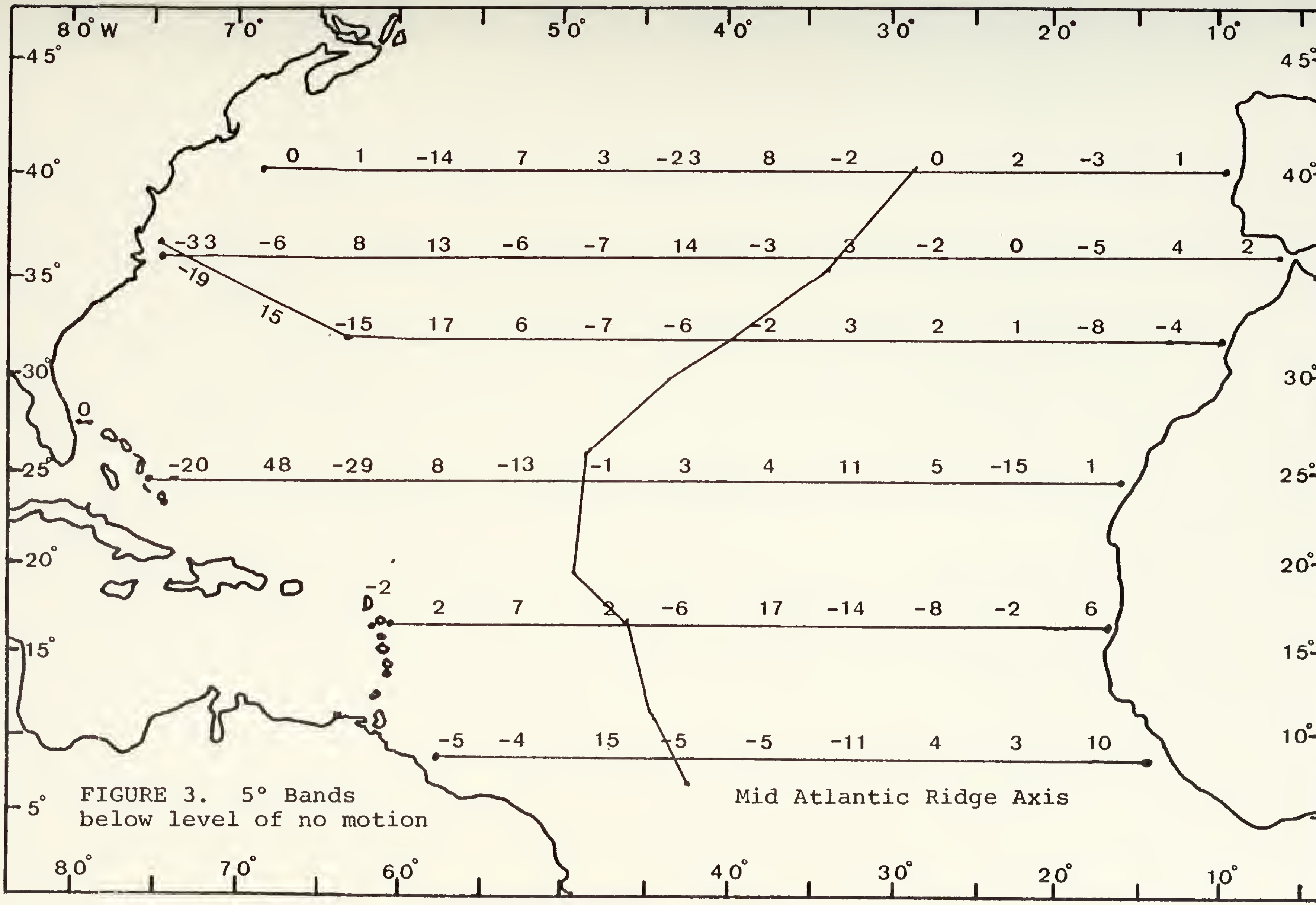



FIGURE 3. 5° Bands below level of no motion

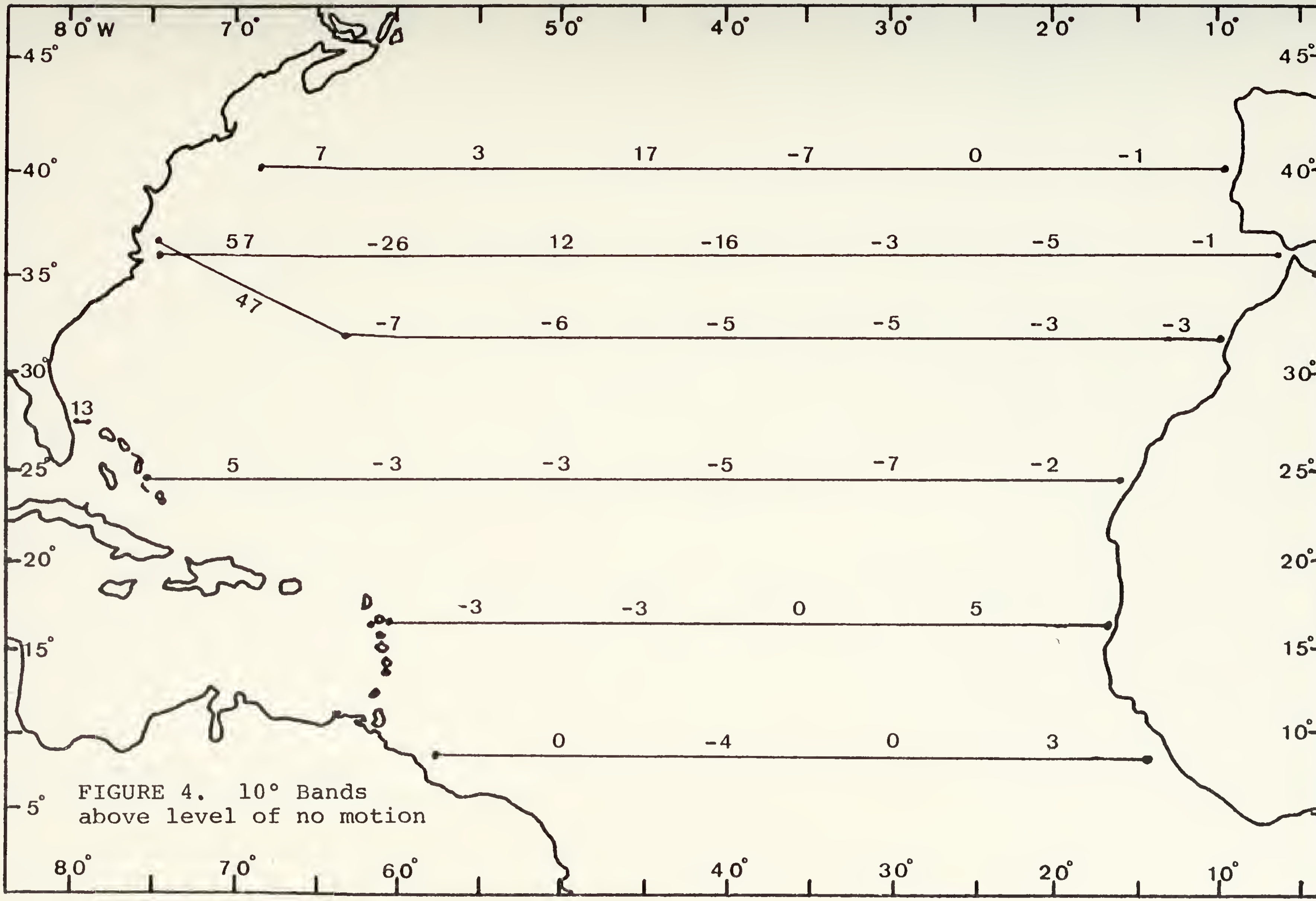



FIGURE 4. 10° Bands above level of no motion

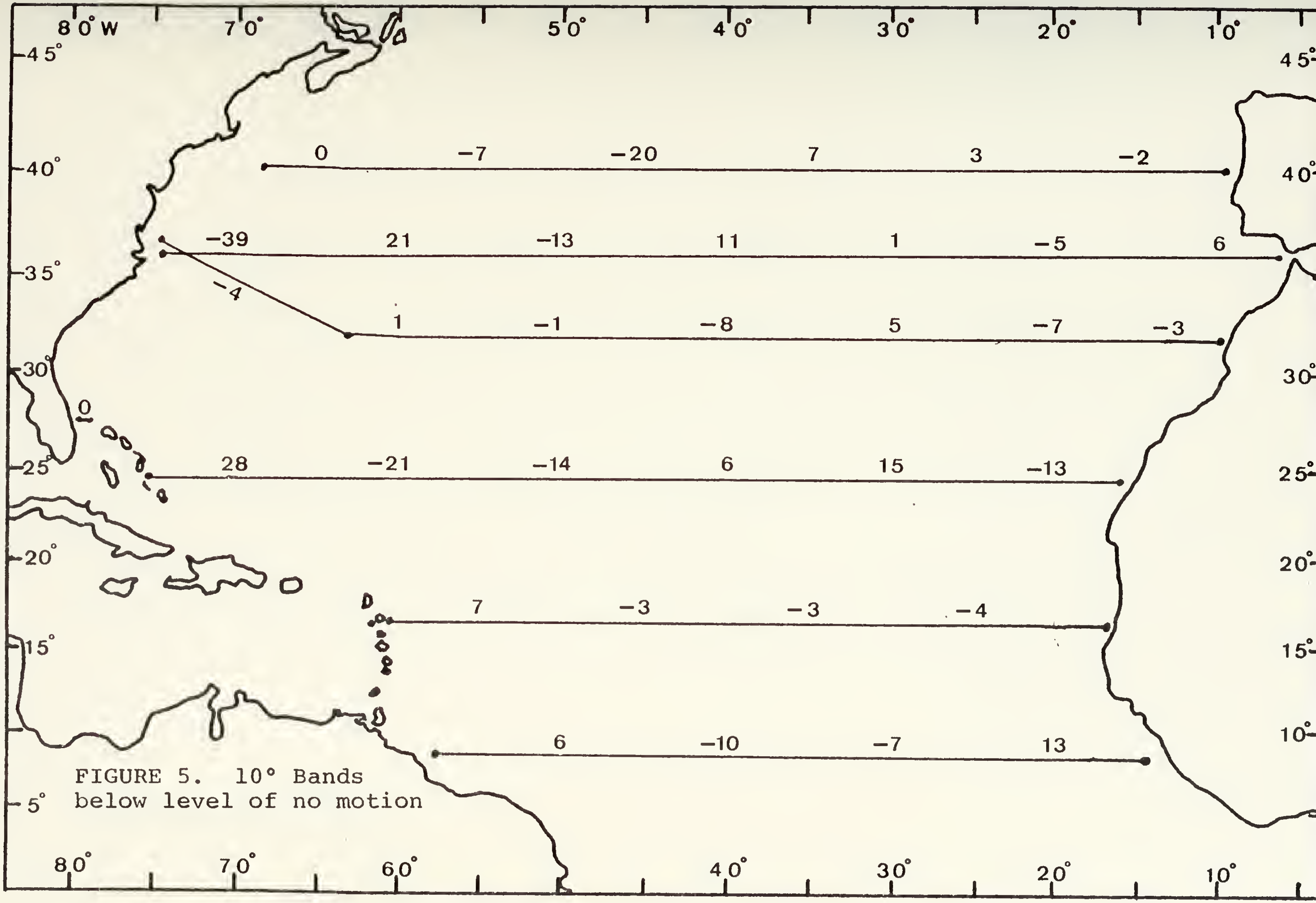



FIGURE 5. 10° Bands below level of no motion

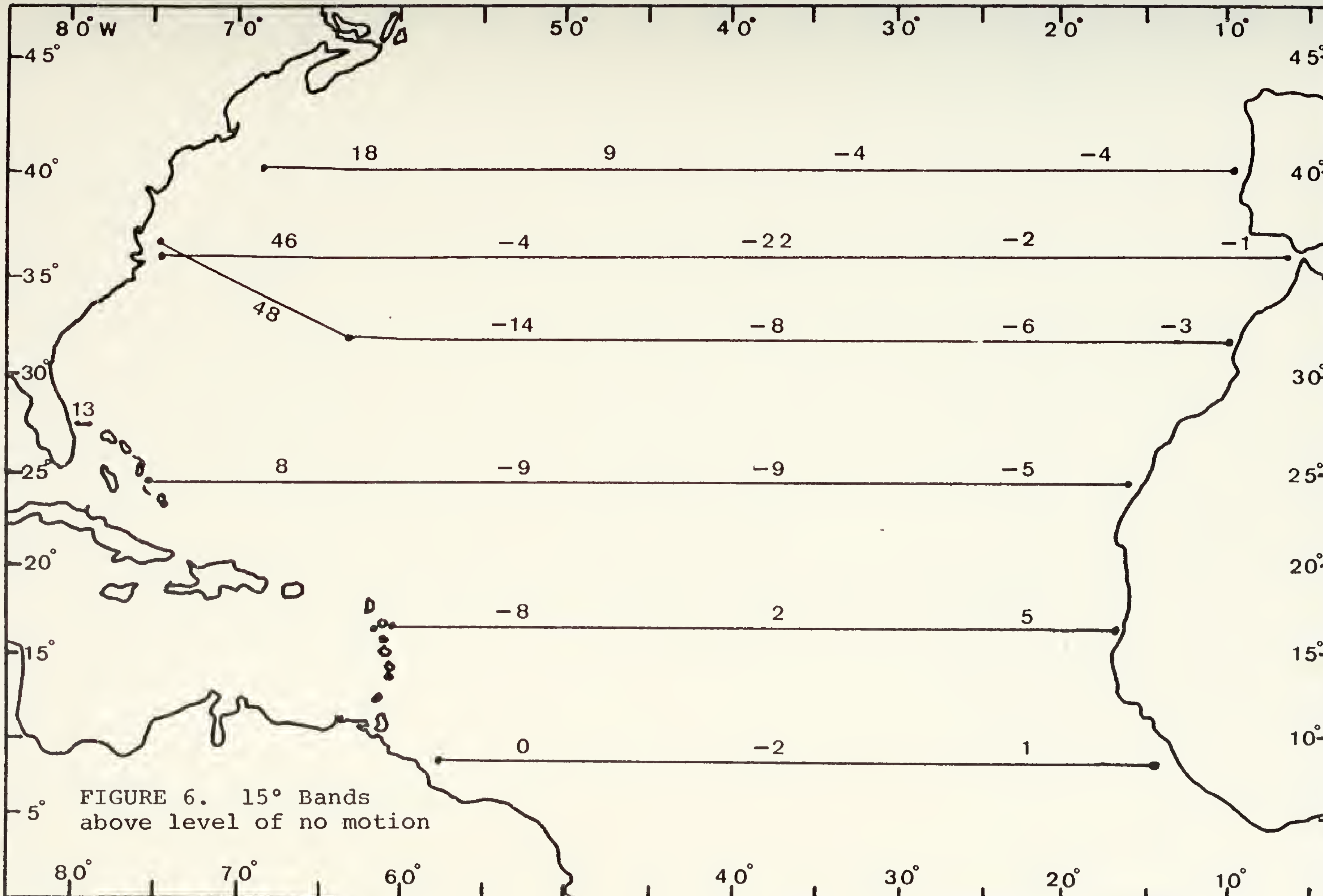



FIGURE 6. 15° Bands
above level of no motion

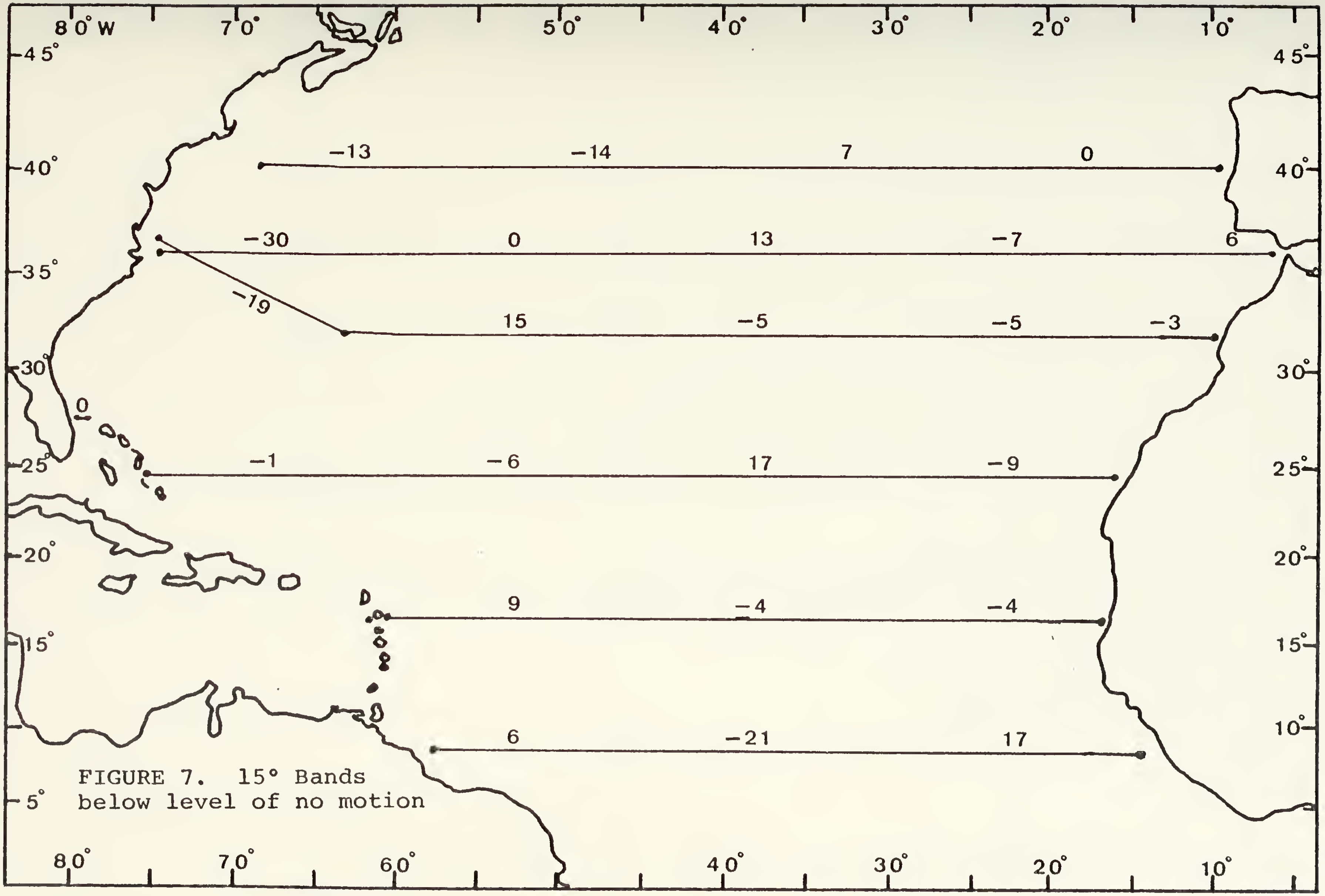



FIGURE 7. 15° Bands below level of no motion

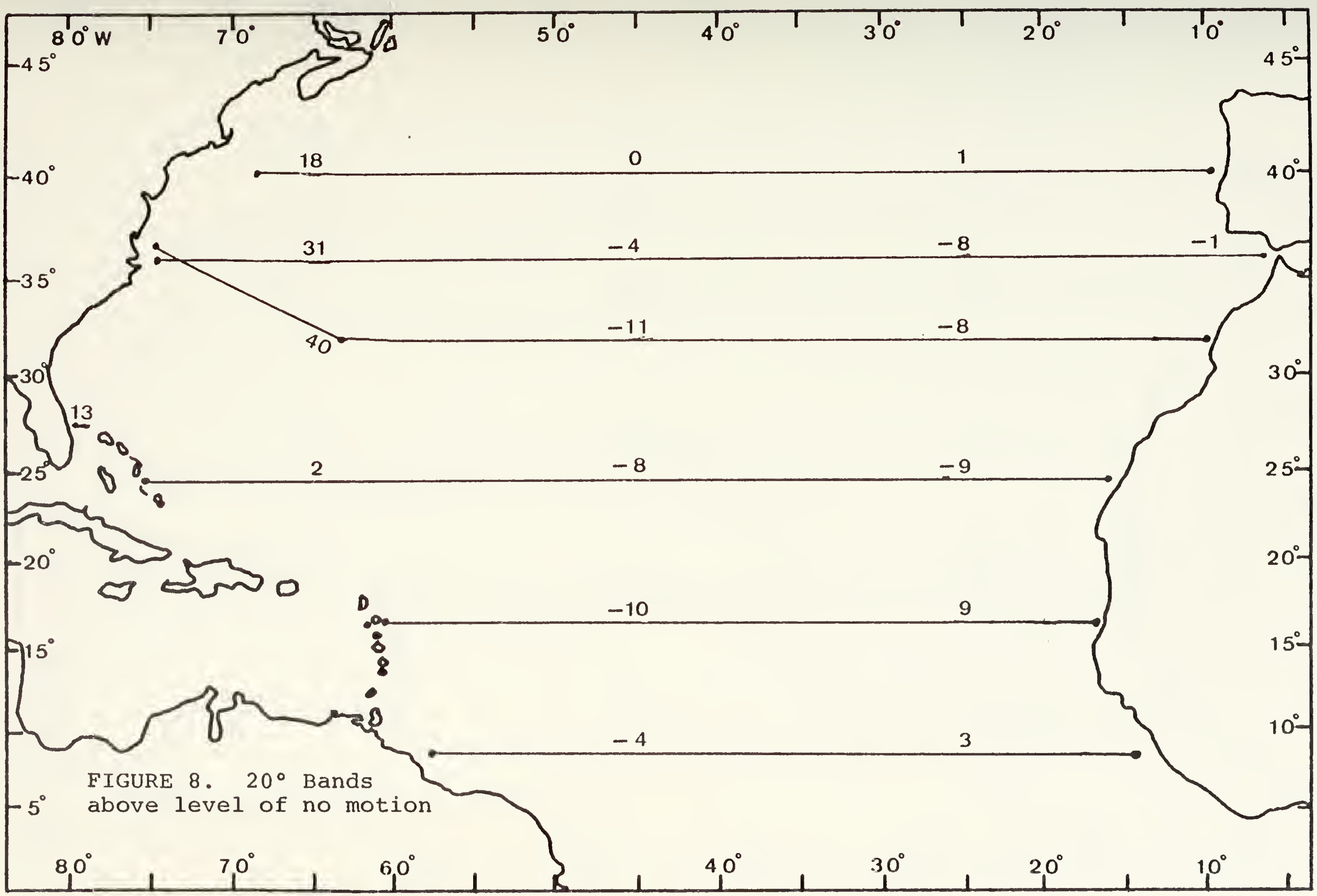



FIGURE 8. 20° Bands
above level of no motion

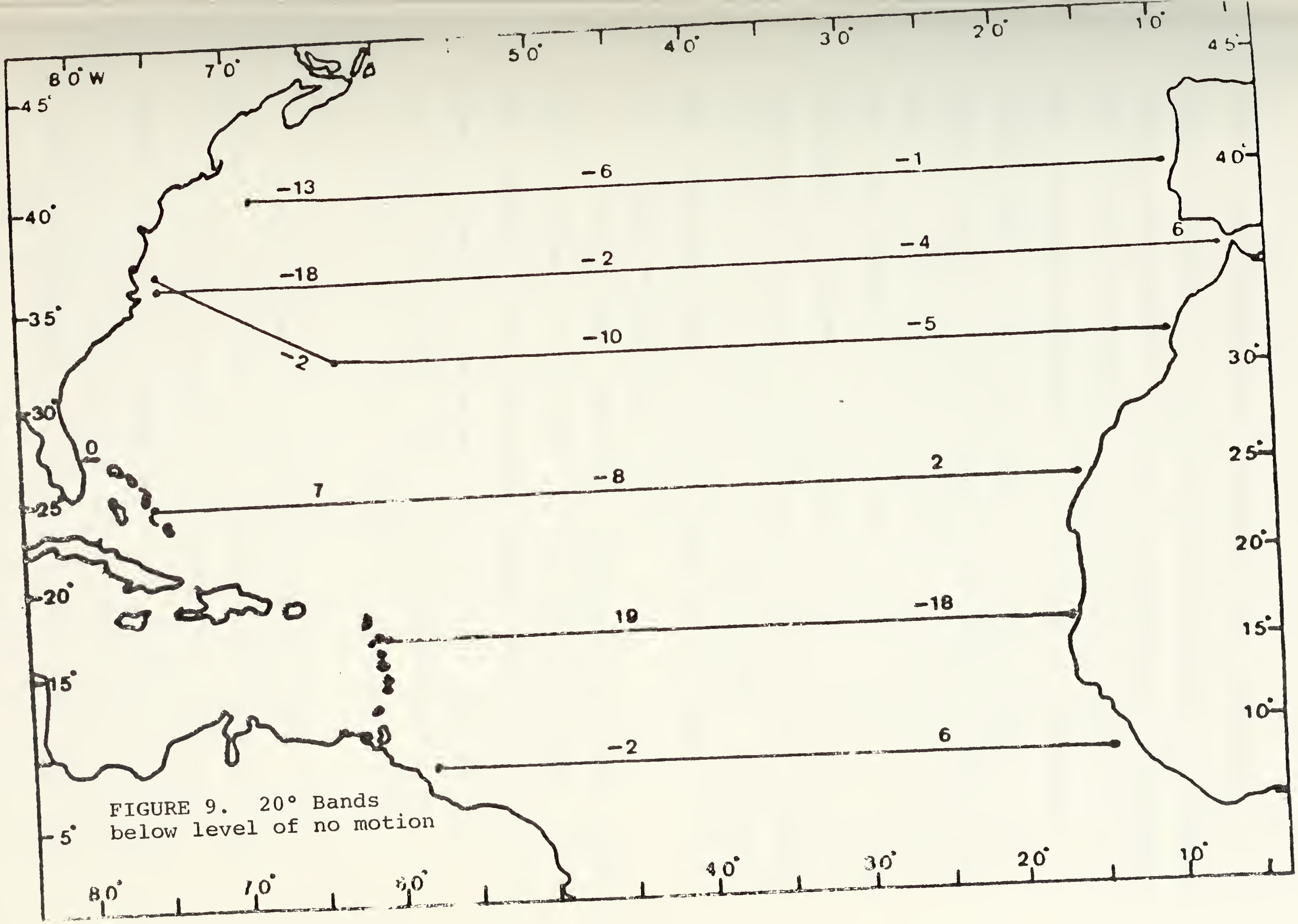



FIGURE 9. 20° Bands below level of no motion

values. Past transport research has been published primarily in terms of volume transport with units of Sverdrups (or Sv) which equal $10^6$ $m^3$/sec. A sampling of the computed data at various locations indicates that the magnitude of mass transport expressed in $10^{12}$ gm/sec is consistently within about 2.7% of being equal to the magnitude of the volume transport when expressed in Sverdrups. This difference is considered within acceptable limits for comparing the mass transport values expressed here directly to volume transport expressed in Sverdrups, in that it is normally exceeded by the error tolerances given for volume transport estimates; ±3.4% Richardson and Schmitz (1965), ±9% Schmitz and Richardson (1968); ±20-30% Warren and Volkman (1968); ±38% Clarke and Reiniger (1973).

In what follows, the major currents of the North Atlantic region between 8°N and 40°N are examined separately with the exception of the Caribbean Current, which is not included. These currents are examined to see to what quantitative and qualitative degree they can be correlated with the calculated values of mass transport resulting from this study.

The Gulf Stream is the most widely studied of these currents. It also has the advantage of having a defined axis which makes possible the conversion of meridional components to total transports in the direction of flow. For this study the mean axis of the Gulf Stream as published in <u>Gulfstream</u> (1975) has been used. This reference

illustrates the mean axis by separate months so it is possible to obtain a value for the Gulf Stream axis orientation for a latitude section corresponding to the month in which the data were taken.

Florida Current

The Gulf Stream begins with the Florida Current which flows due north through the Straits of Florida.

The only intensive study of fluctuation in flow rate and transport in the Straits of Florida appears to be that of Wertheim (1954) who obtained electrical potential measurements by means of an underwater telegraph cable between Key West and Havana. The potential measurements were then converted to volume transport values.

Wertheim's data gave transport values of the order of 14 Sv in December 1952, 16-18 Sv in September to November 1953 and much higher values at other times, ranging as high as 39 Sv in April 1953. Knauss (1969) reports that these measurements were continued until 1959 and showed variations of 100% in the transport over a period of a few months. Stommel (1965), speaking of these data, pointed out that perhaps the most striking feature of these fluctuations was the extreme rapidity with which major changes in transport can occur.

More recent estimates were made by Richardson and Schmitz (1965). Using a direct measurement instrument, they measured the volume transport across 25°43.5'N as 35.5 ± 1.2 Sv in

August 1964. They found that mid-depth measurements to an average depth of 175m accounted for about one half of the transport and to an average depth of 450m they accounted for nine-tenths of the total. Water deeper than 450m, which was 30% of the cross sectional area, carried the remaining 10% of the northerly transport. They found no evidence of southerly flow in the deep water except for a minor amount on the west side of the strait which they say may have been a tidal flow.

Schmitz and Richardson (1968) again measured the transport in the straits and obtained a steady state volume transport figure of 32 ± 3 Sv, finding that the current penetrates essentially to the bottom.

Richardson et al. (1969) reported further measurements made at 27°26'N in 1966 and 1967 of 33.1 Sv and 33.0 Sv, respectively, again using a direct measurement instrument.

Wunsch et al. (1969) examined fluctuations in the Florida Current by drawing inferences from sea level records and concluded that there was no possibility of the 50% fluctuations of transport of the Gulf Stream as suggested by Wertheim and that, if sea surface slope measurements reflect transport change, the transport varied by at most 25%.

Niiler and Richardson (1973) reported a mean value of 29.5 Sv for the period 1964-1971 with a maximum of 39.2 Sv occurring in the summer of 1965 and a minimum of 19.0 Sv occurring in the winter of 1970.

Discussion of these fluctuations in the Florida Current is germane in that the mass transport value computed for this study across 27°23'N totals only 13.4 Sv.

## Antilles Current

After passing through the Straits of Florida the Florida Current is reinforced by the Antilles Current (Sverdrup et al., 1942) flowing north of the West Indies. Evidence concerning the transport of the Antilles Current is conflicting (Stommel, 1965). Sverdrup quotes Wüst's 1924 estimate of 12 Sv. Heezen (1966) estimates that the Gulf Stream draws over 12 Sv of the Antilles current across the Blake Plateau thus implying that the total transport of the current exceeds 12 Sv. Costin (1968) made direct current measurements at one point in the Antilles Current during 9-22 March 1967. He concluded that the Antilles Current has sufficient magnitude to add considerable volume to the Gulf Stream north of the Straits of Florida. He made no quantitative estimates of the Antilles Current due to a lack of measurements across the current. In the vicinity of 26°45'N, 77°00'W he found NW current flows of over one knot down to 750m. He also suggests that the Antilles Current receives its inflow along its eastern boundary and thus increases its transport from south to north.

This study reflects a 19 Sv northward component of transport above the level of no motion in the vicinity of the northernmost part of the Antilles Current. To the east

there appears an almost equally strong (14 Sv) component of a southerly countercurrent [Fig. 2 ].

The Gulf Stream

The Gulf Stream in the area between the Straits of Florida and Cape Hatteras is not covered by the IGY data, but near Cape Hatteras at 36°N, both the 32°N and 36°N sections cross its axis [Fig. 10 ]. Extensive research has been done in attempts to estimate the transport of the Gulf Stream and its associated counter-and undercurrents. Knauss (1969) presents a summary of volume transport estimates of the Gulf Stream made using geostrophic measurements and neutrally buoyant floats and also measurements of the vertically integrated horizontal velocity using transport floats. For the vicinity of Cape Hatteras he quotes estimates of: 60 Sv, made by Barrett in 1962; 74 Sv, made by Worthington and Wright in 1966; 63 Sv, made by Knauss in 1967; and 74 Sv, made by Knauss in 1965. The last of these he regards as the most uncertain.

In order to compare the results of this study to these earlier estimates it is necessary to select a value for the Gulf Stream axis orientation. The data for the 36°N section were collected during April. For the applicable portion of the 32°N section they were collected during June. An enlarged plot of the axis as depicted in Gulfstream (1975) for these months was used to measure values for the axis orientation. For both months the axis was measured as

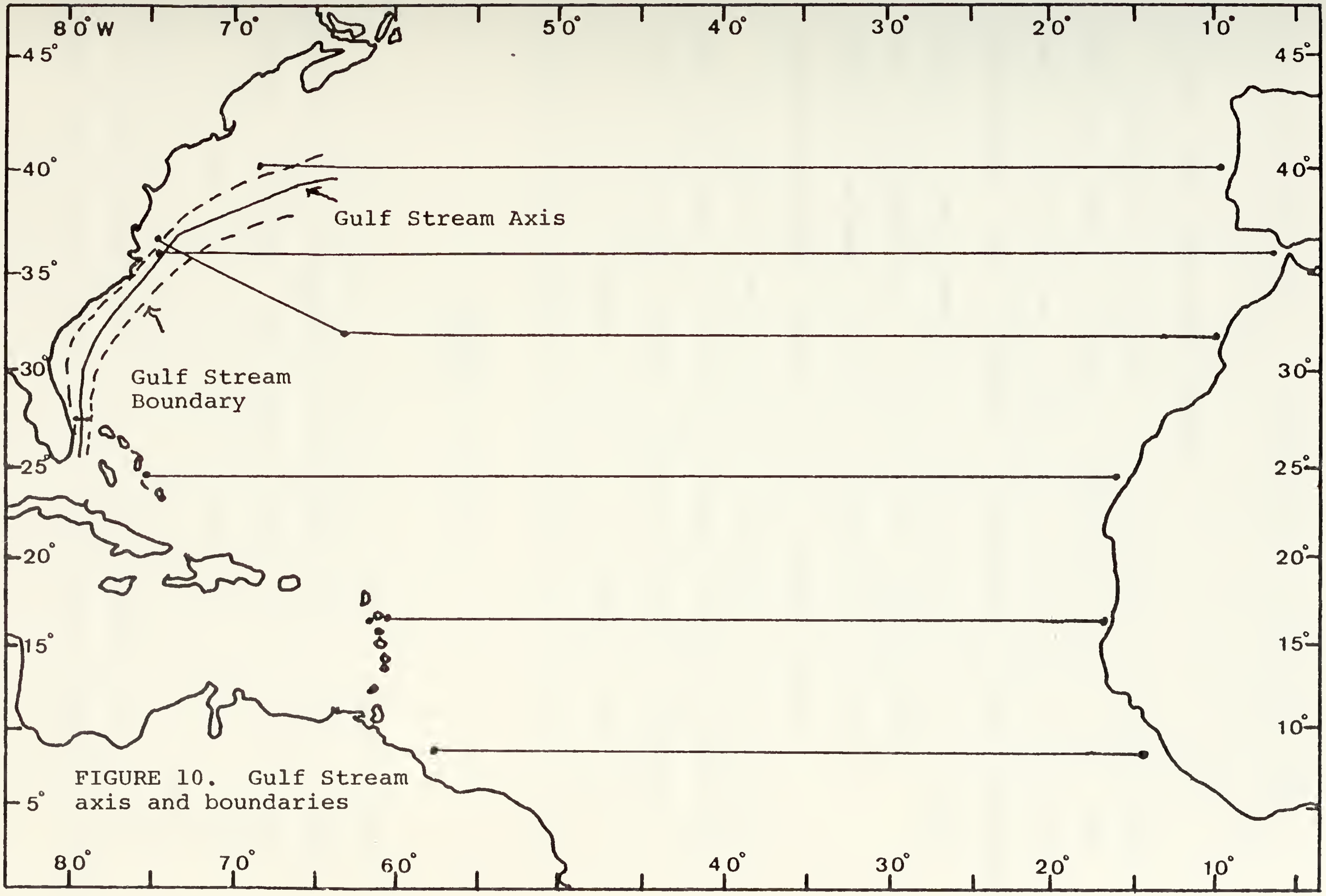



FIGURE 10. Gulf Stream axis and boundaries

oriented toward 049°T. Corroborative evidence for this result was found in Boisvert's (1967) two year mean value of 049°T for this same location.

With an axis selected, it is necessary to choose boundaries for the Gulf Stream. NAVOCEANO Pub. 700 (1965) was used for this purpose. When making quantitative transport comparisons, the 5° longitude increments are not sufficiently precise in the presence of available data on flow orientation and boundaries, so the detailed computations of transport between successive soundings will be used to evaluate transport within the Gulf Stream region.

For the 36°N section the net meridional mass transport above the level of no motion between the approximate boundaries of the Gulf Stream, 71°28'W to 37°55'W (Appendix A), is $42 \times 10^{12}$ gm/sec ≈ 42 Sv. To compute the total transport this component is divided by the cosine of 49°:

$$\frac{42 \text{ Sv}}{\text{Cos } 49°} = 64.0 \text{ Sv}$$

The 32°N section, which actually spans the Gulf Stream at 36°N at its western end, requires only a slightly more complex treatment. The computed flow in this angled leg of the track [Fig. 10 ] is not meridional but is instead perpendicular to the track. This perpendicular direction is oriented toward 065°T and the net transport above the level of no motion between the approximate boundaries of the

Gulf Stream as crossed by this track, 72°15'W to 74°08'W (Appendix A), is equal to 60 x $10^{12}$ gm/sec ≈ 60 Sv. To compute the total transport through this section this component is divided by the cosine of 16°, the difference between 049°T and 065°T:

$$\frac{60 \text{ Sv}}{\text{Cos } 16°} = 62.4 \text{ Sv}$$

The agreement between these two results compared with the results quoted by Knauss is most encouraging.

Transport estimates for the Gulf Stream at the 40°N section pose a more difficult problem due to the predominantly zonal nature of the flow. Past transport estimates in this area vary considerably. Choosing an arbitrary level of no motion of 2000db , Mann (1967) calculated 47 Sv and 52 Sv transported to the east from data taken in April 1963 and June 1964 for longitude 50°W near 40°N. Warren and Volkman (1968) calculated the Gulf Stream transport to be 101 Sv ± 20 to 30% in the vicinity of 38°N and 69°W. Clarke and Reiniger (1973) using current meter data in conjunction with hydrographic data calculated a transport for the Gulf Stream across 49°30'W of 130 ± 50 Sv in the vicinity of 40°N. Knauss (1969) quotes an estimate made by Fuglister in May-June 1960 of 147 Sv in the vicinity of 38°40'N, 64°30'W.

*Gulfstream* (1975) does not depict an axis east of 60°W. West of 60°W it is depicted in *Gulfstream* as being oriented 070°T for the month of October. Boisvert (1967) reports a 072°T orientation just west of 60°W and 088°T just east of 60°W. Mann (1967) indicates that the Gulf Stream turns to the southeast after crossing 50°W (Worthington; 1962) and divides at 38°30'N, 44°W with the main flow going to the southeast and a branch turning back to the northeast. Mann also reports that the stream broadens and slows by the time it reaches 37°N, 42°W and there reaches its end as an identifiable current.

Most of the features of Mann's depiction of the Gulf Stream are apparent in Fig. 2 . The meridional component switches from northerly to southerly in the region between 55°W and 45°W. There is a northward and southward branching as one crosses 45°W and, after crossing 40°W the meridional transport, at least, decreases.

As for making a quantitative comparison of the total Gulf Stream transport in this section to past estimates, it does not appear that this will be possible. The axis of the Gulf Stream as it is usually depicted (Mann, 1967; Boisvert, 1967; NAVOCEANO Pub. 700, 1965; *Gulfstream*) does not cross 40°N except as part of a transient meander. East of 63°W the Gulf Stream begins to meander and is influenced by seamounts (Boisvert, 1967), so any attempt at computing the total transport would only account for some portion of the Gulf Stream north of its axis and would be influenced by meanders.

Azores Current

Boisvert describes the Azores Current as a slow but fairly constant southeast flowing current in the vicinity of the Azores Islands. Sverdrup et al. (1942) in describing the circulation in this region says that the greater amount of the waters of the Gulf Stream turns south before reaching the Azores and circulates around the Sargasso Sea, and that the North Atlantic Current crosses the mid-Atlantic ridge at approximately 45°N then turns to the right and continues as an irregular flow toward the south between the Azores and Spain.

These three features are born out for the circulation above the level of no motion in Fig. 4 where 10° increments of longitude are used. The 5° increment chart [Fig. 2 ], while showing agreement with Sverdrup's description, indicates northward transport components in the immediate vicinity of the Azores contrary to Boisvert's characterization of the flow. A possible explanation for this apparent discrepancy can be found by an examination of the actual station data (Appendix A). At the 40°N section, the net transport in the surface water ($\geq$ 292°K; Sverdrup et al., 1942) is zero in the 25°-30°W and 30°-35°W longitude bands. However, the deeper water masses, North Atlantic Central and transition, have sufficient northward transport in this zone for it to appear when the finer 5° longitude resolution is used.

At 36°N between 25° and 30°W the surface flow is southward between all station pairs except one. There, a strong northward jet covering only 25% of the 5° transect overshadows the other transports resulting in a net transport to the north. Boisvert has relied primarily on surface ship measurements for his current study so the results of this study are not really in conflict with his results to the degree that they initially appear when using 5° longitude increments. Unfortunately, no direct current measurements were located for this region for use in confirming this northward transport.

One would also expect this region to be one of some turbulence due to the relief of the volcanic archipelago making up the Azores.

Portugal Current

Boisvert characterizes the Portugal Current as a slow-moving predominantly southward flow off the Atlantic coasts of Spain and Portugal. The mass transport value obtained for the area above the level of no motion represents a similar flow in this location [Fig. 2 ]. Little is known about the subsurface flow.

Canary Current

The southward transports off the northwest coast of Africa [Fig. 2 ] for the 32°N and 24°N sections are in agreement with Boisvert's description of the southerly flowing Canary Current in this region. However, at the 16°N section

the calculated net transport is to the north above the level of no motion. Boisvert illustrates the Canary Current as narrowing to the south and, as it crosses the 16°N section, extending from approximately 20° to 25°W. Using the same approach as used in dealing with the apparent discrepancy in the Azores Current, the net transport of the surface water in this 5° section (Appendix A) is found to be slightly to the south ($-0.4 \times 10^{12}$ gm/sec ≈ 0.4 Sv) while the deeper North Atlantic Central and transition zone water masses have sufficiently strong northward transports to make the net flow move to the north above the level of no motion. Again, close examination reveals that the geostrophic data are in actual agreement with the prevailing surface current although, when summed to the level of no motion, they show apparent contradiction.

Guinea Current

The eastern end of the 8°N section intersects a portion of the Guinea Current just off the African coast. The geostrophic calculations indicate a near shore northward transport of $5 \times 10^{12}$ gm/sec ≈ 5 Sv between 14°24'W and 15°00'W. The IGY data for this section were collected during May. Boisvert reports surface currents in this area as NE through SE during July, August, and September with NE flow occurring 18.2% of the time. During the winter, December through February, he finds that the current becomes variable and at times reverses, occasionally reaching speeds

of one knot. Little is known about the subsurface flow. The geostrophic data (Appendix A) show 91% of this northward flow occurring below 50m in the North Atlantic Central and transition water masses. Due to the seasonal variability of this current and the small area of its intersection with the IGY data, it is difficult to draw a conclusion. Plutchak in Fairbridge (1966) depicts the circulation in this area as NE in the summer and NW in the winter due to counter-currents landward of the North Equatorial and Canary currents.

Atlantic North Equatorial Current

The Atlantic North Equatorial Current is a broad, slow, west-setting current originating near 26°W and contained between about 15°N and 30°N. It flows across the ocean past 60°W where it forms the Antilles Current (Boisvert, 1967). Only qualitative comparisons can be made here due to the zonal nature of the flow and the lack of available transport estimates. Portions of the 24°N and 16°N sections fall within the zone of this current and, above the level of no motion, compare favorably in several qualitative ways: (1) Sverdrup et al. (1942) point out that the North Equatorial Current, while flowing from east to west, does not follow an absolutely straight course. Surface measurements indicate that the current bends to the north as it approaches the mid-Atlantic ridge and to the south after passing the ridge. This pattern also appears in the results

of this study [Fig. 2 ]. (2) The generally small meridional transport values obtained for this zone [Fig. 2 ] are in agreement with what should be expected for predominantly zonal flow. (3) Between 25°W and 35°W in the 16°N section there appear elements of northward transport while at 24°N between these longitudes the meridional transport is southward. Reporting on seasonal fluctuations in this zone, Boisvert (1967), indicates a prevailing current direction of 285°T (summer) and 275°T (winter) for the 16°N section and a prevailing current direction of 270°T (summer) and 255°T (winter) for the 24°N section between these longitudes. The IGY data for this portion of the two sections were collected in the autumn. In both cases the net meridional transport agrees in direction with Boisvert's prevailing currents.

## Guiana Current

The Guiana Current off the northeast coast of South America is a shallow wind driven current which according to Plutchak in Fairbridge (1966) is undetectable below 137m. For this reason it is not examined in this study.

## Deep Ocean

Transport estimates in the deep ocean, below the level of no motion, are rare; however, one study bears such similarity in results to this study that it should be mentioned. Richardson (1974) undertook to resolve how the Gulf Stream and the Western Boundary Undercurrent (Swallow and Worthington,

1961) apparently cross at Cape Hatteras. He conducted his research slightly to the south of where the 32°N IGY section data were collected. Using hydrographic data and deep current measurements he obtained the two results of 47 and 49 Sv for the total Gulf Stream transport within its boundaries as he found them in May, June, and July 1971. For the area directly below these Gulf Stream limits he calculated a corresponding reverse transport by the Western Boundary Undercurrent of 16 and 17 Sv; when these values are added to the upper Gulf Stream transport values, the resulting net transports through the section are 31 and 32 Sv, northeastward.

Although the numbers cited in the present study for the Gulf Stream transport disagree with Richardson's numbers, further examination does reveal an interesting point of similarity for net transport results. A computation of the transport below the level of no motion between the bounds used earlier to determine the 32°N section Gulf Stream transport yields a transport of 29 x $10^{12}$ gm/sec ≈ 29 Sv (Appendix A) toward 245°T. The resulting Gulf Stream transport along the previously used 049°T axis is:

$$\frac{-\ 29\ \mathrm{Sv}}{\mathrm{Cos}\ 16^\circ} = -\ 30\ \mathrm{Sv}$$

This, when summed with the 62.4 Sv value obtained for the Gulf Stream above the level of no motion, results in

a net axial transport of 32.4 Sv toward 049°T, through a section bounded by the Gulf Stream's surface boundaries extended to the bottom. The agreement with Richardson's 1974 net results is remarkable.

Kolesnikov et al. (1966) were skeptical of using the dynamic method for computing the deep ocean circulation. They agreed that for a properly chosen level of no motion the dynamic method would yield satisfactory results when compiling charts of steady currents in the upper layer of the ocean. However, since the dynamic method does not take friction into consideration, they rejected it for use in obtaining a correct picture of the deep circulation. They also characterized deep currents as being streamlike in nature wherein the water surrounding such a stream often runs in the opposite direction. They indicated that in this case a satisfactory selection of a level of no motion would be impossible even with the aid of directly measured currents. They concluded, "... at best therefore, the dynamic method ... will merely serve to detect a deep current in the ocean, but will give an incorrect characterization of its velocity and transport."

This view is in direct contradiction to the assumptions of the present study; here it is postulated that frictional effects will not extend any appreciable distance above the bottom boundary and that the level of no motion can be established as a relatively stationary surface that can be

used to calculate deep ocean currents. In fact, the deep calculations of the present study correspond remarkably well with the current structure described by Kolesnikov in following sections where he refers to Defant's (1961) description of the deep North Atlantic water mass. They describe it as occupying an extensive part of the North Atlantic at depths greater than 1000m and extending in three traceable branches. The weakest branch is described as extending along the east Atlantic basin from the Canaries to the Cape Verde Islands and apparently penetrating to the Gulf of Guinea. The second or middle branch they depict as extending south along the east slope of the mid-Atlantic ridge to 5°N. They describe the third and strongest branch as hugging the continental slope of North America and passing through the North Atlantic Basin to the east of the Antilles.

These three features are detectable in Fig. 3 in the sections south of 40°N with the exception that no weak branch penetration is apparent near the Gulf of Guinea.

## B. CURRENTS

The comparison of directly measured currents to the calculated geostrophic currents was made subject to the following rules:

(1) After the directly-measured currents were converted, where necessary, to cm/sec and resolved into their meridional components they, along with their geostrophic counterparts, were rounded to the nearest whole cm/sec.

(2) Comparisons were then classified into one of three categories:

| | | Designation |
|---|---|---|
| a. | Agreement in both direction and magnitude | 0 0 |
| b. | Agreement in direction but not magnitude | 0 X |
| c. | Agreement in neither direction nor magnitude | X X |

(3) Comparison of direction required no establishment of judgment criteria. Flows were either to the north or to the south with northerly flow considered as in the + direction. Rounded current values of zero were counted as both + and - for direction comparisons.

(4) Comparison of magnitude was made according to the following criteria:

a. Current speeds of less than or equal to 5 cm/sec were considered to be in agreement in magnitude but only if they were already of the proper direction.

b. Above 5 cm/sec a "doubling" rule was applied. If the smaller of two compared values was equal to at least half of the other, the two were considered as in agreement in magnitude. In these cases a prerequisite for proper direction was also made. Due to the range of measured and computed current values which fell, with some exceptions, primarily between 0 and 20 cm/sec, an order of magnitude approach would not have provided a meaningful comparison.

The geographic distribution of the 110 current values used to make the comparison is illustrated in Fig. 11.

Data meeting the criteria for inclusion in this study are very sparse since they are only a portion of the already sparse body of data on directly-measured ocean currents.

Seventy five percent of the data lie in the western Atlantic. The 16°N section has only 8 measurements, all in the same geographical location, and the 8°N section has none at all. It is perhaps fortunate that the concentration occurred in the vicinity of the Gulf Stream since it is there that the level of no motion takes on its greatest importance when computing mass transport.

An examination of those currents which fell within the approximate boundaries of the Gulf Stream (NAVOCEANO Pub. 700, 1965) was made relative to the computed geostrophic currents. Of 20 such measurements, 85% were in the right direction and 77% of those were also of the right magnitude. However, 11 of the 20 were surface measurements made in the Straits of Florida using free drop instruments for durations of only five minutes (Chew et al., 1971). Since this measurement technique was unique among the current data the same comparison was made with these measurements excluded. In this second comparison, 78% of the measurements were in the right direction and 71% of those were also of the right magnitude.

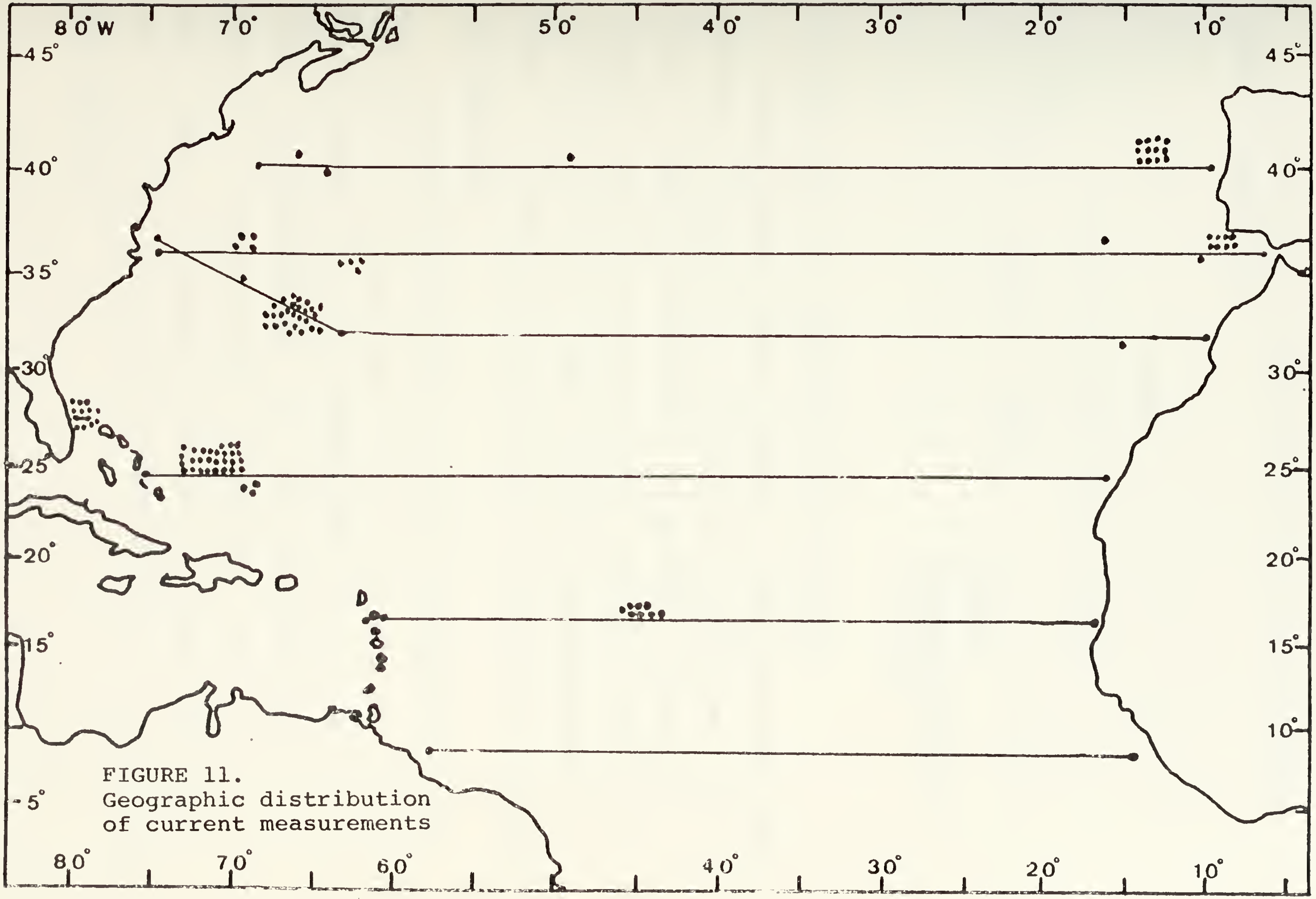



FIGURE 11.
Geographic distribution
of current measurements

The distribution among the three classifications is shown in Table IV .

TABLE IV

Currents within the Gulf Stream

| O O | O X | X X | |
|---|---|---|---|
| 13 | 4 | 3 | (TOTAL) |
| 5 | 2 | 2 | (WITHOUT STRAITS OF FLA. DATA) |

In either case, the comparison was favorable.

For the entire region a series of comparisons were made between the measured and calculated current values. The first of these was the overall correlation. Of the 110 compared values of current velocity, 75% are in the right direction and 73% of those are of the proper magnitude. Table V illustrates the breakdown by latitude and category of comparison.

It should be noted that 9 of the 27 measurements which disagreed in both magnitude and direction were made at a single station at 32°N. The data for that station are taken from NAVOCEANO Pub. 700 (1965) and the date and duration of the measurement are unknown. However, the measurement is characterized as being of good reliability so it could not be eliminated under the criteria established in Section IV.

TABLE V

Overall Current Comparison

| | OO | OX | XX | TOTAL POINTS |
|---|---|---|---|---|
| 40° | 13 (93%) | 0 | 1 (7 %) | 14 |
| 36° | 11 (61%) | 5 (28%) | 2 (11%) | 18 |
| 32° | 7 (25%) | 9 (32%) | 12 (43%) | 28 |
| 24° | 23 (55%) | 7 (17%) | 12 (29%) | 42 |
| 16° | 6 (75%) | 2 (25%) | 0 | 8 |
| 8° | 0 | 0 | 0 | 0 |
| | 60 (54%) | 23 (21%) | 27 (25%) | 110 (100%) |

The fact that more than half of the data correlated in both magnitude and direction in spite of the spread of data over several years was encouraging.

The next examination of the data was a correlation by depth.

Table VI shows the distribution of the 110 datum points by category and depth in 1000m increments.

TABLE (VI)

Current Comparison by Depth; Distribution

| DEPTH (m) | CATEGORY O O | O X | X X | TOTAL | TOTAL PERCENT | CUMULATIVE PERCENT |
|---|---|---|---|---|---|---|
| 0-1000 | 33 | 15 | 15 | 63 | 57 | 57 |
| 1000-2000 | 9 | 3 | 8 | 20 | 18 | 75 |
| 2000-3000 | 9 | 3 | 0 | 12 | 11 | 86 |
| 3000-4000 | 3 | 2 | 1 | 6 | 6 | 92 |
| 4000-5000 | 3 | 0 | 1 | 4 | 4 | 96 |
| > 5000 | 3 | 0 | 2 | 5 | 4 | 100 |
| TOTAL | 60 | 23 | 27 | 110 | | |

It is not surprising to find that the concentration of data drops off rapidly with increasing depth.

Table VII shows the distribution by category and depth in terms of percent per category in individual layers.

TABLE VII

Current Comparison by Depth; Percentages

| DEPTH (m) | CATEGORY O O | O X | X X | TOTAL |
|---|---|---|---|---|
| 0-1000 | 52% | 24% | 24% | 100% |
| 1000-2000 | 45% | 15% | 40% | 100% |
| 2000-3000 | 75% | 25% | 0% | 100% |
| 3000-4000 | 50% | 33% | 17% | 100% |
| 4000-5000 | 75% | 0% | 25% | 100% |
| > 5000 | 60% | 0% | 40% | 100% |

The only significant observations to be made from the depth correlation attempt are that, (1) in all depth intervals, a majority of the data falls within the first category (agreement in direction and magnitude) and (2) in all depth intervals but one, this majority is equal to or greater than the number of datum points in the second and third categories combined.

There does not appear to be a decrease in correlation with increasing depth as one might expect to find as a result of the difficulty involved in making accurate deep ocean measurements. If anything, it would appear that the

percentage of favorable comparisons generally increased with depth. However, the sparseness of datum points in levels below 3000m renders the use of percentage calculations less meaningful in those regions.

Next examined was the difference in time of year between the IGY data and current measurements collection times. Table VIII shows this distribution by category and time separation.

TABLE VIII

Current Comparison by Season; Distribution

| | RELATIVE TIME OF YEAR | O O | O X | X X | TOTAL |
|---|---|---|---|---|---|
| Case I | Within same month | 10 | 4 | 3 | 17 |
| Case II | Within 1 month | 8 | 4 | 10 | 22 |
| Case III | Within 2-3 months | 26 | 10 | 12 | 48 |
| Case IV | Within 4-6 months | 16 | 5 | 2 | 23 |
| | | | | | 110 |

Table (IX) shows the individual and cumulative distribution of the total in terms of percentages.

TABLE IX

Current Comparison by Season; Percentages

| RELATIVE TIME OF YEAR | INDIVIDUAL | CUMULATIVE |
|---|---|---|
| Within same month | 15% | 15% |
| Within 1 month | 20% | 35% |
| Within 2-3 months | 44% | 79% |
| Within 4-6 months | 21% | 100% |

A favorable comparison occurred for all differences in collection times except for the data in Case II. However, it should be noted that the data within this group are heavily influenced by a single station. Nine of the ten X X (disagreement in direction and magnitude) datum points in Case II came from the same 32°N station which was discussed earlier in this section.

Based on the data used for this study, it does not appear that seasonal time separation is a determining factor in the correlation of the measured and computed current velocities. Such a conclusion is made cautiously, however, due to the questionable assumption, inherent in an examination such as this, that environmental conditions are always similar for a given month. It must be noted that data shown here for a given month may have been taken in several different years.

In order to obtain a sufficient number of usable datum points to conduct this study, it is necessary to make use of all the available records of direct current measurements. It is interesting to examine the effect of the passage of years on the degree of correlation between the IGY data of the late 1950's and the measured current data of the coincident and subsequent years as illustrated in Table X by category and five-year time increments.

TABLE X

Current Comparison by Years; Distribution

| TIME OF DIRECT CURRENT MEASUREMENTS | O O | O X | X X | TOTAL |
|---|---|---|---|---|
| 1955-1959 | 19 | 4 | 2 | 25 |
| 1960-1964 | 4 | 7 | 1 | 12 |
| 1965-1969 | 24 | 7 | 12 | 43 |
| 1970-1974 | 6 | 0 | 3 | 9 |
| | | | | 89 |

In this examination only 89 points are usable due to the elimination of those data for which the year of record was not available. Table XI shows the distribution in terms of percentage of the total for the same time increments but for a slightly different representation of the categories. (Category 0 - shows all data which agrees in direction.)

TABLE XI

Current Comparison by Years; Percentages

| DIRECT CURRENT MEASUREMENTS | 0 0 | 0 - |
|---|---|---|
| 1955-1959 | 75% | 92% |
| 1960-1964 | 33% | 92% |
| 1965-1969 | 57% | 72% |
| 1970-1974 | 66% | 66% |

The best correlation [Table XI] in both direction and magnitude occurred for the time interval coinciding most nearly with that of the IGY data. No subsequent chronological trend is apparent, but if agreement in direction is the only parameter considered, one does emerge as shown by the column headed 0 - . The agreement in direction is progressively poorer during the time intervals outside the decade which included the IGY.

Pochapsky (1968) writes that, "Most of our knowledge on water movements in the deep ocean is derived from classical measurements of the temperatures and salinities present. Such measurements make it possible to calculate the average current structure... These determinations can only represent averages over times measured in years. Although relatively few measurements, scattered in time, are used, they are internally consistent and show little variation over periods of decades. This procedure thus reveals a reasonably stationary velocity structure." Based on the limited amount of data used

for this study, it would appear that the IGY data, as employed here, are able to represent long term averages in direction quite well. It is more difficult to make a conclusive statement concerning magnitude because of the subjective nature of establishing magnitude correlation criteria.

Those measured currents which fell within the zone of the chosen level of no motion (900-1300m) were also examined. This provided another check on the validity of the choice of this reference level in addition to the check resulting from the net mass and salt fluxes converging toward zero in the computer output.

Eleven datum points fell within this zone and are displayed in Table XII. Eighty-two percent agreed with the calculated values in direction and 66% of these were also of the proper magnitude.

TABLE XII

Currents Near Level of No Motion

| DEPTH | 0 0 | 0 X | X X | TOTAL |
|---|---|---|---|---|
| 900-1300m | 6 | 3 | 2 | 11 |

While this agreement is reassuring, the data are insufficient for making generalizations about the location of the level of no motion. More substantial evidence supporting the chosen location lies elsewhere.

## C. GENERAL CIRCULATION

Figures 12 and 13 represent a proposed general circulation pattern for the North Atlantic Ocean above and below the level of no motion respectively. They are derived from the mass transport field as it appears in Figs. 2 and 3 in 5° increments of longitude.

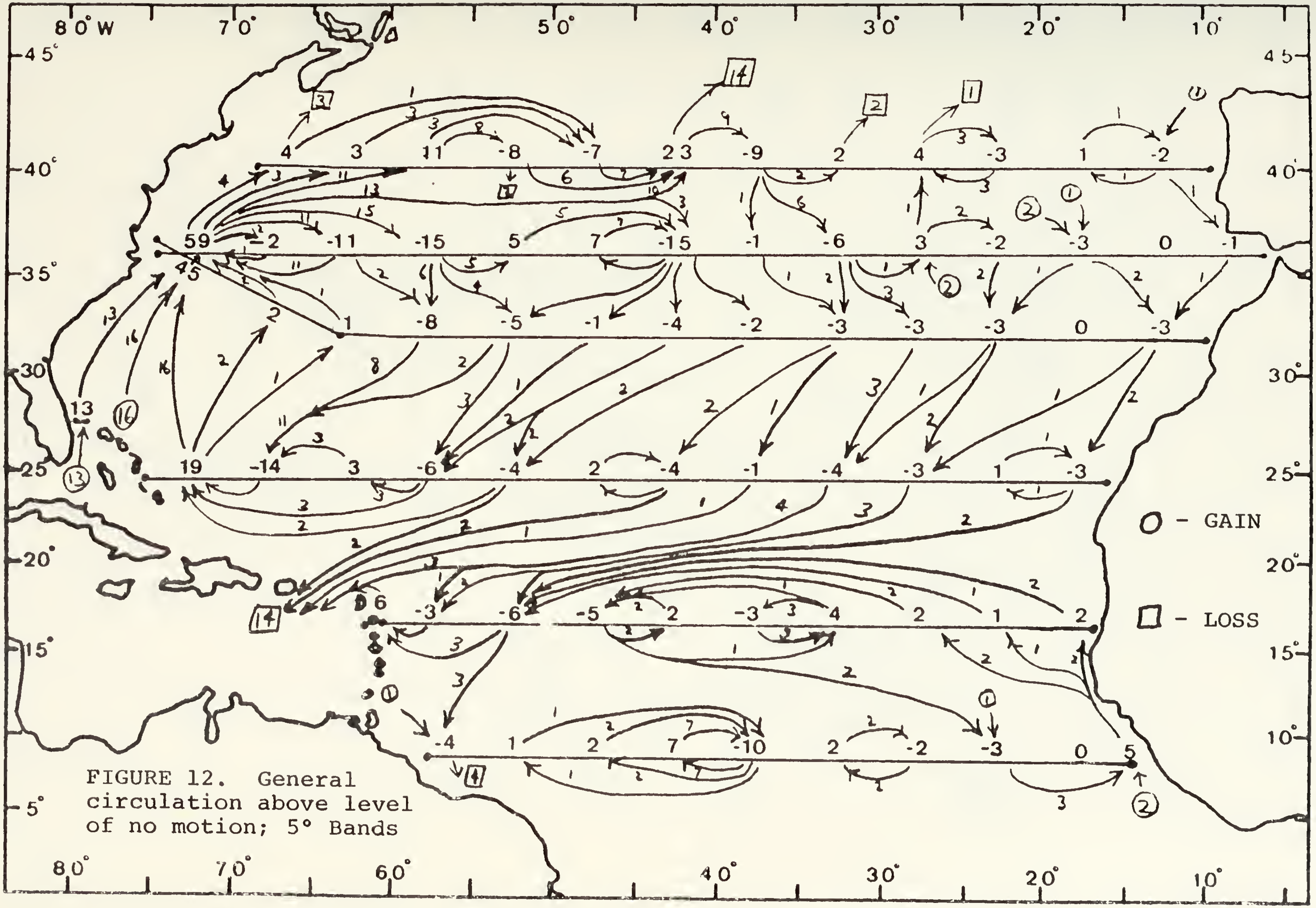



FIGURE 12. General circulation above level of no motion; 5° Bands

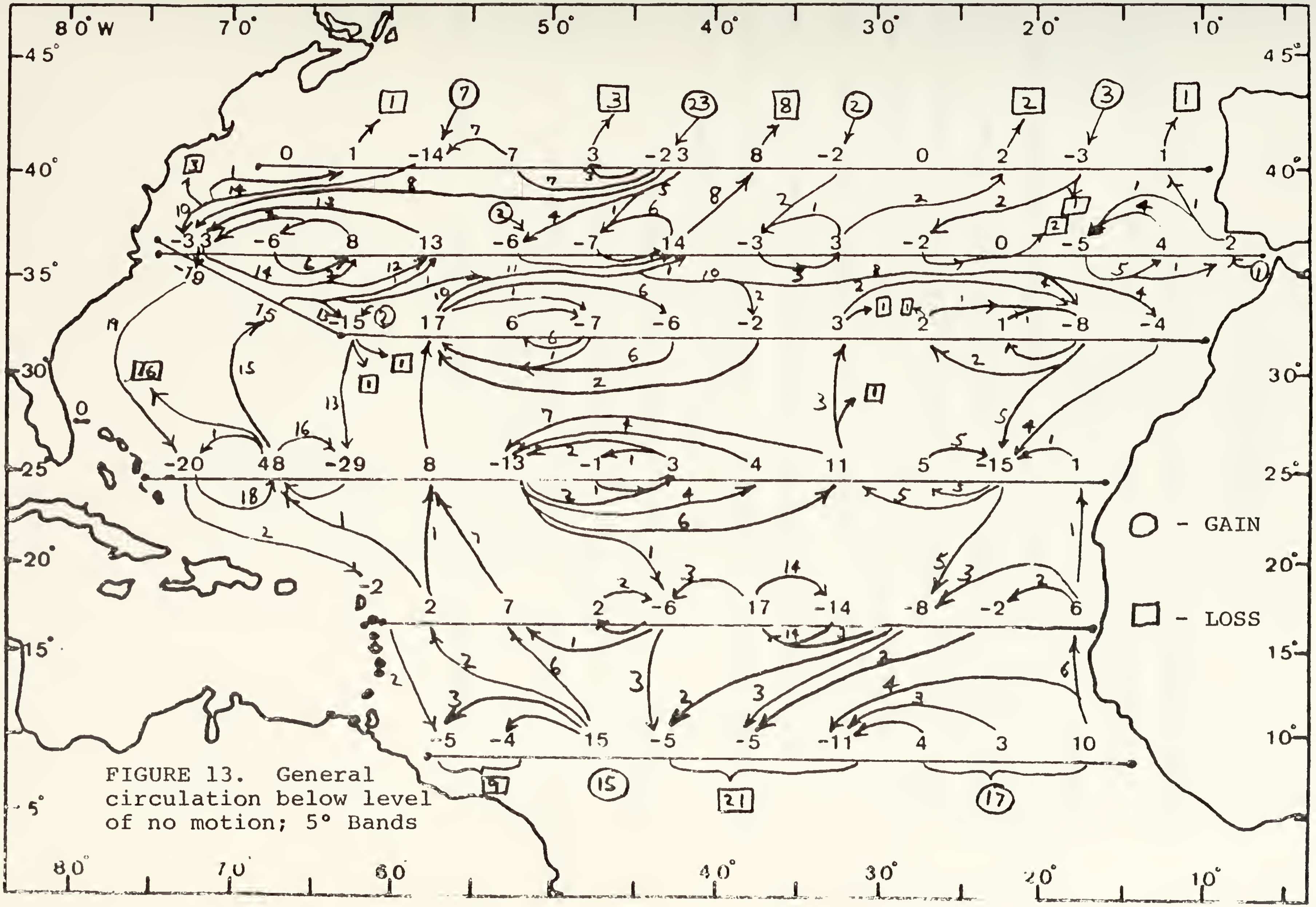



FIGURE 13. General circulation below level of no motion; 5° Bands

# VI. CONCLUSIONS

There is considerable evidence that a geostrophically-calculated description of the North Atlantic general circulation, based on a level of no motion that lies near 1100m, compares favorably when correlated by comparison to past transport estimates, past descriptions of the general circulation, and direct current measurements while having the singular advantage of maintaining the necessary continuity of total mass transport in the ocean. Salt transport continuity has also been observed in determining the configuration of the level of no motion that has been used in the geostrophic calculations.

IGY hydrographic data exists for the areas to the north and south of the region examined in the present study. Similar examinations of these areas would provide information as to the extent of applicability of the level of no motion used herein to larger areas of the world's oceans.

# APPENDIX A

## GEOSTROPHIC DATA

FORMAT:

STATION NUMBERS (Fuglister, 1960)

station spacing (km)
level of no motion (m)
depth (m)
longitude of first (westernmost) station
mass transport above level of no motion ($x10^{12}$ gm/sec)

mass transport below level of no motion ($x10^{12}$ gm/sec)

absolute mass transport ($x10^{12}$ gm/sec)

### 40°N

| 218-219 | 219-220 | 220-221 | 221-222 |
|---|---|---|---|
| 38.34 | 53.92 | 73.74 | 153.18 |
| 150 | 850 | 1150 | 1200 |
| 150 | 850 | 1800 | 3000 |
| 68°25'W | 67°58'W | 67°26'W | 66°28'W |
| -0.04789 | 7.83945 | -3.57885 | -0.18145 |
| --- | --- | 0.11188 | -0.53674 |
| -0.04789 | 7.83945 | -3.46697 | -0.71819 |

| 222-223 | 223-224 | 224-225 | 225-226 |
|---|---|---|---|
| 147.53 | 155.04 | 131.00 | 164.70 |
| 1200 | 1200 | 1200 | 1250 |
| 4500 | 4250 | 4250 | 4750 |
| 64°40'W | 62°56'W | 61°07'W | 59°35'W |
| 11.82217 | -9.85904 | 0.18736 | -1.52682 |
| -9.23450 | 9.00276 | 1.14059 | -6.88177 |
| 2.58764 | 0.14372 | 1.32795 | -8.40859 |

| 226-227 | 227-228 | 228-229 | 229-230 |
|---|---|---|---|
| 142.03 | 151.72 | 162.02 | 136.32 |
| 1200 | 1300 | 1200 | 1200 |
| 4500 | 4500 | 5000 | 4750 |
| 57°29'W | 55°59'W | 54°12'W | 52°18'W |
| 31.82933 | -34.78986 | 2.45288 | -1.81167 |
| -4.55198 | 13.91240 | 0.70737 | 2.78103 |
| 17.27735 | -20.87746 | 3.16025 | 0.96936 |

| 230-231 | 231-232 | 232-233 | 233-234 |
|---|---|---|---|
| 144.80 | 153.18 | 133.65 | 170.93 |
| 1200 | 1250 | 1200 | 1250 |
| 3750 | 3750 | 3750 | 4250 |
| 50°42'W | 49°00'W | 47°12'W | 45°39'W |
| 17.11329 | -14.86578 | -7.15548 | 16.06710 |
| -7.46372 | 5.22856 | 7.37085 | -16.60581 |
| 9.64967 | -9.63722 | -0.21537 | -0.53871 |

| 234-235 | 235-236 | 236-237 | 237-238 |
|---|---|---|---|
| 147.49 | 139.13 | 147.59 | 156.11 |
| 1250 | 1200 | 1200 | 1200 |
| 4500 | 4750 | 4250 | 4250 |
| 43°40'W | 41°56'W | 40°18'W | 38°34'W |
| 26.16417 | -11.04717 | -14.31090 | 10.64651 |
| -16.97613 | 1.75312 | 19.93071 | -17.26838 |
| 9.18804 | -9.29405 | 5.61981 | -6.62187 |

| 238-239 | 239-240 | 240-241 | 241-242 |
|---|---|---|---|
| 150.35 | 148.93 | 147.48 | 143.25 |
| 1250 | 1250 | 1250 | 1200 |
| 4000 | 3250 | 2000 | 1500 |
| 36°44'W | 34°58'W | 33°13'W | 31°29'W |
| -8.04099 | 8.92607 | -7.15248 | 0.12476 |
| 9.34198 | -1.93909 | 0.10571 | -0.07764 |
| 1.30099 | 6.98698 | -7.04677 | 0.04712 |

| 242-243 | 243-244 | 244-245 | 245-246 |
|---|---|---|---|
| 156.02 | 148.93 | 151.92 | 151.92 |
| 1100 | 1200 | 1150 | 1200 |
| 1500 | 2000 | 2750 | 3500 |
| 29°48'W | 27°58'W | 26°13'W | 24°27'W |
| 1.95566 | 3.61170 | -2.75791 | -0.21772 |
| -0.07513 | -0.67318 | 1.64392 | 1.45004 |
| 1.88053 | 2.93852 | -1.11399 | 1.23232 |

| | | | |
|---|---|---|---|
| 246-247 | 247-248 | 248-249 | 249-250 |
| 143.27 | 153.20 | 150.46 | 141.86 |
| 1200 | 1200 | 1200 | 1200 |
| 3750 | 3750 | 5000 | 5000 |
| 22°41'W | 21°00'W | 19°12'W | 17°26'W |
| -4.90653 | 5.02945 | -0.22717 | -1.15176 |
| 2.99537 | -4.58096 | -2.57239 | 1.54079 |
| -1.91116 | 0.44849 | -2.79956 | 0.38903 |

| | | | |
|---|---|---|---|
| 250-251 | 251-252 | 252-253 | 253-254 |
| 150.40 | 157.47 | 112.06 | 80.84 |
| 1200 | 1200 | 1150 | 1100 |
| 5000 | 5000 | 4750 | 1800 |
| 15°46'W | 14°00'W | 12°09'W | 10°50'W |
| -0.61390 | -0.37759 | -0.85932 | 0.02380 |
| 0.22461 | 2.45360 | -0.59483 | -1.16038 |
| -0.38929 | 2.07601 | -1.45415 | -1.13658 |

| |
|---|
| 254-255 |
| 28.60 |
| 150 |
| 150 |
| 9°53'W - 9°33'W |
| -0.08380 |
| -- |
| -0.08380 |

36°N

| | | | |
|---|---|---|---|
| 18-19 | 19-20 | 20-21 | 21-22 |
| 21.05 | 19.56 | 19.48 | 19.48 |
| 100 | 700 | 1000 | 1000 |
| 100 | 1300 | 2000 | 2250 |
| 74°48'W | 74°34'W | 74°21'W | 74°08'W |
| -0.03601 | 0.26040 | -1.26018 | 1.46733 |
| --- | 0.05090 | 0.37312 | -0.07027 |
| -0.03601 | 0.31130 | -0.88706 | 1.39706 |

| 22-23 | 23-24 | 24-25 | 25-26 |
|---|---|---|---|
| 17.98 | 16.48 | 18.08 | 19.83 |
| 1000 | 1000 | 1000 | 1000 |
| 2500 | 2500 | 3000 | 3000 |
| 73°55'W | 73°43'W | 73°32'W | 73°20'W |
| -1.72471 | -0.54054 | -0.38650 | 0.27070 |
| 1.18138 | -0.16425 | -0.72880 | 0.44972 |
| -0.54333 | -0.70479 | -1.11530 | 0.72042 |

| 26-27 | 27-28 | 28-29 | 29-30 |
|---|---|---|---|
| 16.58 | 31.67 | 31.93 | 36.69 |
| 1000 | 1100 | 1100 | 1100 |
| 3000 | 3500 | 3500 | 3500 |
| 73°07'W | 72°56'W | 72°35'W | 72°14'W |
| 0.33399 | 2.45254 | 5.64904 | 21.17875 |
| -0.13493 | -0.43064 | -3.42516 | -9.86562 |
| 0.19906 | 2.02190 | 2.22388 | 11.31313 |

| 30-31 | 31-32 | 32-33 | 33-34 |
|---|---|---|---|
| 32.96 | 39.00 | 52.56 | 70.96 |
| 1100 | 1200 | 1100 | 1100 |
| 3750 | 3750 | 4250 | 4250 |
| 71°50'W | 71°28'W | 71°02'W | 70°27'W |
| 14.70086 | -15.27845 | 22.87322 | 16.06218 |
| -5.23040 | 4.55946 | -8.87647 | -18.73867 |
| 9.47046 | -10.71899 | 13.99675 | -2.67649 |

| 34-35 | 35-36 | 36-37 | 37-38 |
|---|---|---|---|
| 117.12 | 155.91 | 142.37 | 148.57 |
| 1100 | 1100 | 1100 | 1100 |
| 4250 | 4500 | 4500 | 4500 |
| 69°40'W | 68°22'W | 66°38'W | 65°03'W |
| -3.45333 | -1.31392 | -3.28155 | -23.49861 |
| -1.27953 | 3.58799 | -0.40970 | 19.76746 |
| -4.73286 | 2.27407 | -3.69125 | -3.73115 |

| 38-39 | 39-40 | 40-41 | 41-42 |
|---|---|---|---|
| 143.80 | 151.34 | 160.81 | 135.54 |
| 1100 | 1100 | 1200 | 1100 |
| 4500 | 4500 | 4500 | 5000 |
| 63°24'W | 61°48'W | 60°07'W | 58°20'W |
| 19.56290 | -6.68638 | -17.83850 | 3.17350 |
| -15.76562 | 4.14564 | 8.78843 | -4.53909 |
| 3.79728 | -2.54074 | -9.05007 | -1.36559 |

| 42-43 | 43-44 | 44-45 | 45-46 |
|---|---|---|---|
| 149.83 | 143.90 | 154.31 | 163.46 |
| 1100 | 1100 | 1100 | 1100 |
| 5250 | 5250 | 5000 | 4750 |
| 56°50'W | 55°10'W | 53°34'W | 51°51'W |
| -2.01171 | 1.71422 | -11.41561 | 14.55354 |
| 9.65682 | -4.95319 | 14.23493 | -15.36910 |
| 7.64511 | -3.23897 | 2.81927 | -0.81556 |

| 46-47 | 47-48 | 48-49 | 49-50 |
|---|---|---|---|
| 151.73 | 139.71 | 147.17 | 151.45 |
| 1100 | 1100 | 1100 | 1100 |
| 4750 | 5000 | 4750 | 4750 |
| 50°02'W | 48°21'W | 46°49'W | 45°11'W |
| 12.83053 | 13.63197 | -16.50219 | -28.84374 |
| -15.55964 | -12.96120 | 18.42074 | 25.17393 |
| -2.72911 | 0.67077 | 1.91855 | -3.66981 |

| 50-51 | 51-52 | 52-53 | 53-54 |
|---|---|---|---|
| 151.13 | 156.21 | 153.04 | 127.60 |
| 1100 | 1100 | 1100 | 1100 |
| 4250 | 3750 | 3250 | 3250 |
| 43°30'W | 41°50'W | 41°06'W | 38°24'W |
| 14.95323 | -4.31895 | 2.58442 | 3.69765 |
| -10.14405 | 1.77220 | -1.25827 | -1.35417 |
| 4.80918 | -2.54675 | 1.32615 | 2.34348 |

| 54-55 | 55-56 | 56-57 | 57-58 |
|---|---|---|---|
| 145.99 | 139.38 | 158.84 | 148.30 |
| 1100 | 1100 | 1100 | 1100 |
| 2000 | 2000 | 2500 | 2000 |
| 36°59'W | 35°22'W | 33°49'W | 32°03'W |
| -6.67360 | -0.51950 | -1.43723 | -5.32302 |
| -0.64115 | -0.11321 | 2.31867 | 0.39817 |
| -7.31475 | -0.63271 | 0.88144 | -4.92485 |

| 58-59 | 59-60 | 60-61 | 61-62 |
|---|---|---|---|
| 149.80 | 157.30 | 139.35 | 146.79 |
| 1100 | 1100 | 1100 | 1100 |
| 2000 | 3250 | 3250 | 3250 |
| 30°24'W | 28°44'W | 26°59'W | 25°26'W |
| 4.18742 | -1.56374 | 1.53345 | -1.65448 |
| -0.11975 | 0.61158 | -2.89928 | 2.02882 |
| 4.06767 | -0.95216 | -1.36583 | 0.37434 |

| 62-63 | 63-64 | 64-65 | 65-66 |
|---|---|---|---|
| 149.85 | 145.31 | 146.93 | 151.42 |
| 1100 | 1250 | 1100 | 1100 |
| 3250 | 4750 | 5000 | 5000 |
| 23°48'W | 22°08'W | 20°31'W | 18°53'W |
| 3.02713 | -4.16419 | 0.65731 | 2.11683 |
| -0.92918 | 0.11575 | -1.74649 | -5.00445 |
| 2.09795 | -4.04844 | -1.08918 | -2.88762 |

| 66-67 | 67-68 | 68-69 | 69-70 |
|---|---|---|---|
| 151.30 | 147.05 | 148.55 | 149.80 |
| 1100 | 1200 | 1100 | 1100 |
| 3000 | 3000 | 3500 | 3500 |
| 17°12'W | 15°31'W | 13°53'W | 12°14'W |
| -4.26183 | -2.36767 | 0.96763 | 2.98284 |
| 1.11616 | 0.32260 | -1.72458 | 1.46798 |
| -3.14567 | -2.04507 | -0.75695 | 4.45082 |

| 70-71 | 71-72 | 72-73 | 73-74 |
|---|---|---|---|
| 91.39 | 74.92 | 52.46 | 5.45 |
| 1150 | 1000 | 700 | 400 |
| 3500 | 2250 | 1300 | 800 |
| 10°34'W | 9°33'W | 8°43'W | 8°08'W |
| -4.78944 | 0.83797 | 1.34036 | 0.10362 |
| 7.08377 | -1.50471 | -0.80563 | 0.09606 |
| 2.29433 | -0.66674 | 0.53473 | 0.19968 |

| 74-75 | 75-76 | 76-77 |
|---|---|---|
| 53.93 | 22.40 | 20.19 |
| 500 | 150 | 50 |
| 750 | 150 | 50 |
| 7°31'W | 6°55'W | 6°42'W - 6°30'W |
| -0.49298 | -0.20211 | 0.00605 |
| 0.85353 | -- | -- |
| 0.36055 | -0.20211 | 0.00605 |

## 32°N

| 5293-5294 | 5294-5295 | 5295-5296 | 5296-5297 |
|---|---|---|---|
| 19.34 | 20.14 | 19.37 | 16.67 |
| 50 | 700 | 1000 | 1000 |
| 50 | 1300 | 1900 | 2000 |
| 74°44'W | 74°32'W | 74°20'W | 74°08'W |
| 0.02976 | -0.10345 | 0.74757 | 2.30028 |
| -- | -0.11743 | -0.25772 | 0.01702 |
| 0.02976 | -0.22088 | 0.48985 | 2.31730 |

| 5297-5298 | 5298-5299 | 5299-5301 | 5301-5302 |
|---|---|---|---|
| 20.79 | 28.15 | 47.50 | 40.54 |
| 1000 | 1000 | 1000 | 1000 |
| 2250 | 2250 | 2500 | 3500 |
| 73°58'W | 73°45'W | 73°29'W | 73°01'W |
| 5.69601 | 24.34020 | 19.89317 | 4.40468 |
| -0.74058 | -2.22136 | -9.62924 | -11.19191 |
| 4.95543 | 22.11884 | 10.26393 | -6.78723 |

| 5302-5303 | 5303-5304 | 5304-5305 | 5305-5306 |
|---|---|---|---|
| 36.29 | 59.67 | 72.98 | 73.18 |
| 1000 | 1100 | 1100 | 1100 |
| 3500 | 3750 | 3750 | 4250 |
| 72°37'W | 72°15'W | 71°44'W | 71°00'W |
| 2.93004 | -1.07241 | -7.59595 | -5.11655 |
| -3.89986 | 0.16966 | 6.91104 | 0.94522 |
| -0.96982 | -0.90275 | -0.68491 | -4.17130 |

| 5306-5307 | 5307-5308 | 5308-5309 | 5309-5310 |
|---|---|---|---|
| 69.83 | 80.92 | 68.80 | 73.20 |
| 1100 | 1100 | 1000 | 1000 |
| 4750 | 4750 | 5000 | 5000 |
| 70°16'W | 69°34'W | 68°47'W | 68°10'W |
| -3.47508 | 10.77327 | 0.95512 | 1.44368 |
| 3.79526 | -3.74534 | 1.12351 | -7.70593 |
| 0.32018 | 7.02797 | 2.07863 | -6.26225 |

| 5310-5311 | 5311-5312 | 5312-5564 | 5564-5203 |
|---|---|---|---|
| 86.23 | 68.87 | 171.18 | 127.30 |
| 1100 | 1000 | 1100 | 1100 |
| 5000 | 4750 | 2750 | 2750 |
| 67°24'W | 66°37'W | 65°57'W | 64°22'W |
| 5.01600 | -12.29608 | -2.99400 | 2.04744 |
| -4.52763 | 26.87981 | 1.03757 | -2.12675 |
| 0.48837 | 14.58373 | -1.95643 | -0.07931 |

| 5203-5204 | 5204-5205 | 5205-5206 | 5206-5207 |
|---|---|---|---|
| 168.53 | 174.82 | 153.12 | 167.19 |
| 1100 | 1000 | 1000 | 1100 |
| 4000 | 4500 | 5000 | 5250 |
| 63°30'W | 61°16'W | 59°25'W | 57°48'W |
| -6.90777 | 10.65819 | 0.40475 | -14.02590 |
| 8.22173 | -31.66206 | 13.64588 | 11.09761 |
| 1.31396 | -21.00387 | 14.05063 | -2.92829 |

| 5207-5208 | 5208-5209 | 5209-5210 | 5210-3625 |
|---|---|---|---|
| 181.47 | 158.09 | 162.19 | 28.34 |
| 1100 | 1100 | 1100 | 1100 |
| 5250 | 5250 | 4750 | 4750 |
| 56°20'W | 54°07'W | 52°27'W | 50°44'W |
| 3.92514 | -3.95130 | -5.21376 | 2.43127 |
| 2.87942 | 3.01458 | 6.14809 | -1.35551 |
| 6.80456 | -0.93672 | 0.93433 | 1.07576 |

| 3625-3626 | 3626-3627 | 3627-3628 | 3628-3629 |
|---|---|---|---|
| 161.80 | 152.40 | 168.26 | 158.83 |
| 1000 | 1100 | 1100 | 1100 |
| 4750 | 4500 | 4000 | 3250 |
| 50°25'W | 48°42'W | 47°05'W | 45°18'W |
| 1.00637 | 3.69709 | -3.77835 | -10.29656 |
| -12.82400 | -4.02798 | 6.15863 | 1.72891 |
| -11.81763 | -0.33089 | 2.38028 | -8.56765 |

| 3629-3630 | 3630-3631 | 3631-3632 | 3632-3633 |
|---|---|---|---|
| 180.68 | 175.94 | 179.08 | 179.06 |
| 1000 | 1000 | 1100 | 1100 |
| 3000 | 2750 | 2750 | 2750 |
| 43°37'W | 41°42'W | 39°50'W | 37°56'W |
| 6.17570 | -1.50432 | 0.48910 | -2.45865 |
| -6.81337 | -0.75866 | 1.69458 | -2.44585 |
| -0.63767 | -2.26298 | 2.18368 | -4.90450 |

| 3633-3634 | 3634-3635 | 3635-3636 | 3636-3637 |
|---|---|---|---|
| 171.16 | 158.60 | 165.11 | 155.63 |
| 1100 | 1000 | 1000 | 1100 |
| 2750 | 2750 | 3500 | 3500 |
| 36°02'W | 34°13'W | 32°32'W | 30°47'W |
| 0.83478 | -0.89212 | -0.50775 | -3.31599 |
| -2.38431 | -2.35540 | 5.49823 | 1.61016 |
| -0.54953 | -3.24752 | 4.99048 | -1.70583 |

| 3637-3638 | 3638-3639 | 3639-3640 | 3640-3641 |
|---|---|---|---|
| 179.05 | 177.55 | 171.26 | 149.54 |
| 1100 | 1100 | 1100 | 1100 |
| 2750 | 2750 | 5000 | 5000 |
| 29°08'W | 27°14'W | 25°21'W | 23°32'W |
| 1.64143 | -2.33371 | -1.33978 | 0.19168 |
| 0.82351 | 2.18467 | -1.31321 | 0.17739 |
| 0.81792 | -0.14903 | -2.65299 | 0.36907 |

| 3641-3642 | 3642-3643 | 3643-3644 | 3644-3645 |
|---|---|---|---|
| 164.93 | 160.20 | 221.46 | 230.36 |
| 1100 | 1100 | 1000 | 1000 |
| 4500 | 4250 | 3750 | 3750 |
| 21°57'W | 20°12'W | 18°30'W | 16°09'W |
| -2.43466 | -0.41240 | 1.38153 | -0.77986 |
| 1.11455 | 6.64806 | -10.63970 | -3.83755 |
| -1.32011 | 6.23566 | -9.25817 | -4.61741 |

| 3645-3646 | 3646-3647 | 3647-3648 | 3648-3649 |
|---|---|---|---|
| 128.77 | 144.47 | 135.10 | 42.41 |
| 1100 | 900 | 500 | 500 |
| 4000 | 3250 | 2500 | 1300 |
| 14°46'W | 13°24'W | 11°52'W | 10°26'W |
| -2.28097 | -1.76893 | 0.81465 | 0.25340 |
| 7.19142 | -4.62167 | -5.32711 | -0.03079 |
| 4.91045 | -6.39060 | -4.51246 | 0.22261 |

| 3649-3650 |
|---|
| 23.63 |
| 100 |
| 100 |
| 9°59'W - 9°44'W |
| -0.14575 |
| -- |
| -0.14575 |

27°N

| 5343-5342 | 5342-5341 | 5341-5340 | 5340-5339 |
|---|---|---|---|
| 5.28 | 5.28 | 3.30 | 9.89 |
| 50 | 150 | 200 | 250 |
| 50 | 150 | 200 | 250 |
| 79°58'W | 79°55'W | 79°52'W | 79°50'W |
| 0.13942 | 0.50617 | 0.93047 | 2.15102 |
| -- | -- | -- | -- |
| 0.13942 | 0.50617 | 0.93047 | 2.15102 |

| 5339-5338 | 5338-5337 | 5337-5336 | 5336-5335 | 5335-5334 |
|---|---|---|---|---|
| 8.24 | 9.89 | 13.19 | 18.23 | 9.89 |
| 350 | 550 | 600 | 350 | 150 |
| 350 | 550 | 600 | 350 | 150 |
| 79°44'W | 79°39'W | 79°33'W | 79°25'W | 79°14'W-79°08'W |
| 2.73575 | 5.22365 | 0.64035 | 0.93802 | 0.08872 |
| -- | -- | -- | -- | -- |
| 2.73575 | 5.22365 | 0.64035 | 0.93802 | 0.08872 |

24°N

| 3624-3623 | 3623-3622 | 3622-3621 | 3621-3620 |
|---|---|---|---|
| 54.08 | 116.60 | 192.62 | 174.13 |
| 1000 | 1100 | 1100 | 1000 |
| 1600 | 4750 | 5250 | 5500 |
| 75°28'W | 74°56'W | 73°47'W | 71°53'W |
| -0.18315 | 3.32004 | 16.09750 | 0.14679 |
| -0.72553 | -15.26833 | 4.30831 | -12.13862 |
| -0.90868 | -11.94829 | 20.40581 | -11.99183 |

| 3620-3619 | 3619-3618 | 3618-3617 | 3617-3616 |
|---|---|---|---|
| 185.87 | 189.34 | 170.63 | 185.94 |
| 1000 | 1100 | 1000 | 1000 |
| 5500 | 5000 | 5000 | 5500 |
| 70°10'W | 68°20'W | 66°28'W | 64°47'W |
| -10.07279 | 1.44649 | -7.43222 | 6.55479 |
| 42.38358 | -10.05802 | 22.50209 | -36.63264 |
| 32.31079 | 8.61153 | 15.06987 | -30.07785 |

| 3616-3615 | 3615-3614 | 3614-3613 | 3613-3612 |
|---|---|---|---|
| 184.30 | 185.86 | 182.51 | 184.11 |
| 1000 | 1100 | 1000 | 1000 |
| 5500 | 5250 | 5250 | 5500 |
| 62°57'W | 61°08'W | 59°18'W | 57°30'W |
| -2.94255 | 1.13580 | -2.44481 | -2.73943 |
| 11.86806 | -11.34196 | 3.49925 | 7.35196 |
| 8.92551 | -10.20616 | 1.05444 | 4.61253 |

| 3612-3611 | 3611-3610 | 3610-3609 | 3609-3608 |
|---|---|---|---|
| 212.93 | 169.69 | 187.87 | 185.88 |
| 1000 | 1100 | 1000 | 1000 |
| 5250 | 4750 | 4250 | 3750 |
| 55°41'W | 53°35'W | 51°55'W | 50°04'W |
| -4.18219 | 2.40805 | -3.88122 | 3.66257 |
| 4.99156 | -0.24536 | -16.11387 | -1.50201 |
| 0.80937 | 2.16269 | -19.99509 | 2.16056 |

| 3608-3607 | 3607-3606 | 3606-3605 | 3605-3604 |
|---|---|---|---|
| 185.88 | 184.13 | 185.82 | 187.55 |
| 1000 | 1000 | 1000 | 1000 |
| 2500 | 2500 | 3500 | 4250 |
| 48°14'W | 46°24'W | 44°35'W | 42°45'W |
| -1.09368 | -0.97991 | -4.17823 | -0.72240 |
| 3.93911 | -4.20131 | -1.13594 | 9.96234 |
| 2.84543 | -5.18122 | -5.31417 | 9.23994 |

| 3604-3603 | 3603-3602 | 3602-3601 | 3601-3600 |
|---|---|---|---|
| 185.77 | 192.81 | 191.01 | 184.18 |
| 1000 | 1000 | 1100 | 1100 |
| 4500 | 4500 | 4750 | 5000 |
| 40°54'W | 39°04'W | 37°10'W | 35°17'W |
| 1.43658 | -3.78455 | 2.50469 | -1.05645 |
| -10.90880 | 20.92738 | -9.33517 | -15.12638 |
| -9.47222 | 17.14283 | -6.83048 | -16.18283 |

| 3600-3599 | 3599-3598 | 3598-3597 | 3597-3596 |
|---|---|---|---|
| 185.81 | 184.10 | 182.80 | 182.64 |
| 1100 | 1000 | 1100 | 1100 |
| 5500 | 5500 | 5500 | 5250 |
| 33°28'W | 31°38'W | 29°48'W | 28°01'W |
| -1.37894 | -1.88167 | -0.19966 | -1.09827 |
| 6.45379 | 19.09568 | -5.77923 | 6.04878 |
| 5.07483 | 17.21401 | -5.97889 | 4.95051 |

| 3596-3595 | 3595-3594 | 3594-3593 | 3593-3592 |
|---|---|---|---|
| 184.13 | 179.06 | 182.71 | 138.91 |
| 1000 | 1100 | 1100 | 900 |
| 4750 | 4750 | 4000 | 3250 |
| 26°13'W | 24°24'W | 22°38'W | 20°50'W |
| -2.72677 | -0.12209 | 2.91696 | -1.61447 |
| 3.53962 | -9.59106 | -7.35920 | 1.932321 |
| 0.80385 | -9.71315 | -4.44224 | 0.31774 |

| 3592-3591 | 3591-3590 | 3590-3589 | 3589-3588 |
|---|---|---|---|
| 95.02 | 87.87 | 67.65 | 45.65 |
| 900 | 500 | 500 | 500 |
| 2750 | 2500 | 1700 | 900 |
| 19°28'W | 18°32'W | 17°40'W | 17°00'W |
| -0.20948 | -1.03255 | -1.50991 | 1.15472 |
| 1.03785 | -0.79358 | 1.31246 | -0.91199 |
| 0.82837 | -1.82613 | -0.19743 | 0.24273 |

| 3588-3587 |
|---|
| 21.96 |
| 100 |
| 100 |
| 16°33'W - 16°20'W |
| -0.25234 |
| -- |
| -0.25234 |

16°N

| 310-309 | 309-308 | 308-307 | 307-306 |
|---|---|---|---|
| 57.04 | 81.98 | 85.60 | 147.99 |
| 300 | 1100 | 1100 | 1100 |
| 300 | 4250 | 2000 | 2000 |
| 61°00'W | 60°28'W | 59°42'W | 58°54'W |
| 0.34769 | 8.92716 | -5.77120 | -5.51417 |
| -- | -3.25396 | -2.28060 | 0.06004 |
| 0.34769 | 5.67320 | -8.05180 | -5.45413 |

| 306-305 | 305-304 | 304-303 | 303-302 |
|---|---|---|---|
| 147.91 | 149.71 | 146.21 | 149.69 |
| 1000 | 1100 | 1000 | 1100 |
| 4750 | 4750 | 4500 | 4500 |
| 57°31'W | 56°08'W | 54°44'W | 53°22'W |
| -1.50137 | 8.03837 | -8.68485 | 2.82897 |
| 12.01825 | -7.45278 | 5.20652 | 4.88782 |
| 10.51688 | 0.58559 | -3.47833 | 7.71679 |

| 302-301 | 301-300 | 300-299 | 299-298 |
|---|---|---|---|
| 153.24 | 146.11 | 146.20 | 147.98 |
| 1100 | 1000 | 1100 | 1000 |
| 3750 | 3000 | 3000 | 2250 |
| 51°58'W | 50°32'W | 49°10'W | 47°48'W |
| -0.53382 | -3.09865 | 2.27070 | 0.44437 |
| -4.01508 | 4.56968 | -6.28682 | 1.90377 |
| -4.54890 | 1.47103 | -4.01612 | 2.34814 |

| 298-297 | 297-296 | 296-295 | 295-294 |
|---|---|---|---|
| 149.67 | 147.90 | 146.10 | 149.72 |
| 1000 | 1100 | 1100 | 1100 |
| 2250 | 3500 | 4500 | 4750 |
| 46°25'W | 45°01'W | 43°38'W | 42°16'W |
| -6.03221 | 4.15470 | 0.38820 | -3.83215 |
| 4.11062 | -11.06240 | 2.80120 | 9.69761 |
| -1.89259 | -6.90770 | 3.18940 | 5.86546 |

| 294-293 | 293-292 | 292-291 | 291-290 |
|---|---|---|---|
| 146.16 | 146.12 | 147.90 | 146.10 |
| 1100 | 1100 | 1100 | 1100 |
| 5000 | 4750 | 4750 | 5250 |
| 40°52'W | 39°30'W | 38°08'W | 36°45'W |
| 1.70785 | 1.51337 | -2.75778 | -2.47526 |
| -12.32393 | -5.33639 | 7.86149 | 16.31385 |
| -10.61608 | -3.82302 | 5.10371 | 13.83859 |

| 290-289 | 289-288 | 288-287 | 287-286 |
|---|---|---|---|
| 140.77 | 155.22 | 137.99 | 158.73 |
| 1100 | 1100 | 1000 | 1100 |
| 5000 | 5000 | 4750 | 4250 |
| 35°23'W | 34°04'W | 32°37'W | 31°20'W |
| -0.82168 | 5.39459 | -0.63624 | -2.37961 |
| 7.52803 | -10.59058 | -9.93375 | 1.51971 |
| 6.70635 | -5.19599 | -10.56999 | -0.85990 |

| 286-285 | 285-284 | 284-283 | 283-282 |
|---|---|---|---|
| 153.30 | 142.61 | 149.68 | 147.90 |
| 1100 | 1000 | 1000 | 1100 |
| 4250 | 4500 | 4250 | 3000 |
| 29°51'W | 28°25'W | 27°05'W | 25°41'W |
| 2.95146 | -3.93735 | 4.85432 | -0.03510 |
| -11.21622 | 16.66959 | -14.96809 | 3.64079 |
| -8.26476 | 12.73224 | -10.11377 | 3.60569 |

| 282-281 | 281-280 | 280-279 | 279-278 |
|---|---|---|---|
| 155.31 | 126.59 | 151.49 | 147.89 |
| 1000 | 1000 | 1100 | 1000 |
| 1100 | 1100 | 3500 | 3250 |
| 24°18'W | 22°52'W | 21°42'W | 20°17'W |
| -3.40635 | 2.61131 | 0.79367 | 4.48784 |
| 0.01468 | -0.03513 | -3.67204 | -0.77138 |
| -3.39167 | 2.57618 | -2.87837 | 3.71646 |

| 278-277 | 277-276 | 276-275 |
|---|---|---|
| 105.20 | 81.98 | 37.83 |
| 1000 | 500 | 150 |
| 2500 | 1600 | 150 |
| 18°54'W | 17°55'W | 17°09'W - 16°48'W |
| 2.18635 | -3.23053 | -0.52783 |
| 0.62128 | 5.57082 | -- |
| 2.80763 | 2.34029 | -0.52783 |

# 8°N

| 184-183 | 183-182 | 182-181 | 181-180 |
|---|---|---|---|
| 91.97 | 101.78 | 86.29 | 96.10 |
| 500 | 1000 | 1000 | 800 |
| 500 | 2000 | 2250 | 1100 |
| 57°42'W | 56°52'W | 55°57'W | 55°10'W |
| -0.32479 | 4.77310 | -7.40835 | -2.52703 |
| -- | -11.09563 | 6.54367 | -1.32347 |
| -0.32479 | -6.32253 | -0.86469 | -3.85050 |

| 180-179 | 179-178 | 178-177 | 177-176 |
|---|---|---|---|
| 91.88 | 91.98 | 191.07 | 181.95 |
| 800 | 800 | 1000 | 1100 |
| 800 | 800 | 2250 | 3750 |
| 54°18'W | 53°28'W | 52°38'W | 50°54'W |
| 3.12971 | 6.77907 | -7.29747 | 1.40125 |
| -- | -- | -2.29785 | -1.52351 |
| 3.12971 | 6.77907 | -9.59532 | -0.12226 |

| 176-175 | 175-174 | 174-173 | 173-172 |
|---|---|---|---|
| 181.79 | 187.31 | 185.52 | 183.65 |
| 1100 | 1100 | 1100 | 1100 |
| 4250 | 4250 | 4250 | 4250 |
| 49°15'W | 47°36'W | 45°54'W | 44°13'W |
| 4.39531 | -8.23116 | 9.38316 | 5.58868 |
| -8.71457 | 34.20177 | -19.14976 | -34.66062 |
| -4.31926 | 25.97061 | -9.76660 | -29.07194 |

| 172-171 | 171-170 | 170-169 | 169-168 |
|---|---|---|---|
| 189.16 | 187.38 | 182.04 | 180.06 |
| 1000 | 1000 | 1100 | 1100 |
| 4250 | 3750 | 3750 | 4000 |
| 42°33'W | 40°50'W | 39°08'W | 37°29'W |
| 0.15808 | -6.54503 | 6.51258 | -13.88036 |
| 22.80693 | 32.14363 | 6.32151 | -29.88167 |
| 22.96501 | 25.59860 | 6.83409 | -43.76203 |

| 168-167 | 167-166 | 166-165 | 165-164 |
|---|---|---|---|
| 185.63 | 196.64 | 174.47 | 181.81 |
| 1100 | 1100 | 1100 | 1100 |
| 4250 | 4000 | 4000 | 4250 |
| 35°51'W | 34°10'W | 32°23'W | 30°48'W |
| 0.35451 | -1.45493 | -0.55958 | 7.01997 |
| 16.59553 | -2.34364 | -20.89746 | 7.93502 |
| 16.95004 | -3.79857 | -21.45704 | 14.95499 |

| 164-163 | 163-162 | 162-161 | 161-160 |
|---|---|---|---|
| 187.86 | 182.71 | 192.86 | 181.80 |
| 1100 | 1100 | 1100 | 1100 |
| 4250 | 4750 | 4750 | 4250 |
| 29°09'W | 27°27'W | 25°48'W | 24°03'W |
| -12.90519 | 5.01347 | 5.45613 | 2.62207 |
| 6.59864 | -5.71207 | -2.52850 | 7.93895 |
| -6.30655 | -0.69860 | 2.92763 | 10.56102 |

| 160-159 | 159-158 | 158-157 | 157-156 |
|---|---|---|---|
| 191.02 | 183.68 | 180.04 | 191.05 |
| 1100 | 1100 | 1100 | 1000 |
| 4000 | 4000 | 4250 | 4000 |
| 22°24'W | 20°40'W | 19°00'W | 17°22'W |
| -7.72016 | -0.86833 | 5.99168 | 0.35555 |
| -2.39700 | -4.11816 | 20.20862 | -7.71274 |
| -10.11716 | -4.98649 | 26.20031 | -7.35719 |

| 156-155 | 155-154 |
|---|---|
| 91.83 | 44.11 |
| 1000 | 900 |
| 3250 | 950 |
| 15°38'W | 14°48'W - 14°24'W |
| -7.14874 | 7.22141 |
| 0.50076 | -0.00002 |
| -7.24798 | 7.22139 |

# APPENDIX B

## TABULATION OF DIRECTLY MEASURED CURRENT DATA USED FOR THIS STUDY

* Current values shown in this table have been resolved into meridional components and rounded to the nearest whole cm/sec.

** Current values for which no year is shown are taken from NAVOCEANO Publication No. 700 (1965)

*** Appendix C includes additional information including the sources of the measured current data

**** Correlation Category

Designation

O O = Agreement in both direction and magnitude

O X = Agreement in direction but not magnitude

X X = Agreement in neither direction nor magnitude

### 40°N

| DATE (Mo.-Yr.) | POSITION (Lat.-Long.) | DEPTH (m) | MEASURED (cm/sec) | CALCULATED (cm/sec) | CORRELATION CATEGORY |
|---|---|---|---|---|---|
| Jun '55 | 41°08'N,14°36'W | 400 | 1 | 0 | 0 0 |
| Jun '55 | 41°08'N,14°36'W | 900 | -2 | 0 | 0 0 |
| Jun '55 | 41°09'N,14°36'W | 630 | 1 | 0 | 0 0 |
| Jun '55 | 41°08'N,14°35'W | 1100 | -4 | 0 | 0 0 |
| May-Jul '58 | 41°25'N,14°30'W | 1560 | -3 | 0 | 0 0 |
| May-Jul '58 | 41°25'N,14°30'W | 2120 | -4 | 0 | 0 0 |
| May-Jul '58 | 41°25'N,14°30'W | 2460 | 0 | 0 | 0 0 |
| May-Jul '58 | 41°25'N,14°30'W | 2760 | 0 | 0 | 0 0 |
| May-Jul '58 | 41°25'N,14°30'W | 2940 | -1 | 0 | 0 0 |
| May-Jul '58 | 41°25'N,14°30'W | 3680 | -2 | 0 | 0 0 |
| May-Jul '58 | 41°25'N,14°30'W | 4240 | -2 | 0 | 0 0 |
| Jun '69 | 40°34'N,65°31'W | 3638 | -4 to -14 | -3 | 0 0 |
| Jun '69 | 39°41'N,63°48'W | 4894 | -6 to -9 | -3 | 0 0 |
| Jun '70 | 40°30'N,49°30'W | 3780 | 4 | -3 | X X |

<u>36°N</u>

| DATE (Mo.-Yr.) | POSITION (Lat.-Long.) | DEPTH (m) | MEASURED (cm/sec) | CALCULATED (cm/sec) | CORRELATION CATEGORY |
|---|---|---|---|---|---|
| Oct '55 | 35°24'N,11°28'W | 1150 | 9 | 0 | 0 X |
| Aug '56 | 36°39'N,17°19'W | 2900 | -1 | -1 | 0 0 |
| Nov '58 | 35°47'N,8°40'W | 1260 | -3 | -3 | 0 0 |
| Nov '58 | 36°27'N,8°54'W | 1080 | -5 | 0 | 0 0 |
| Nov '58 | 36°31'N,8°53'W | 1290 | -7 | -1 | 0 X |
| Jul '59 | 36°50'N,68°30'W | 1330 | -9 | 0 | 0 X |
| Jul '59 | 36°47'N,68°30'W | 2160 | -5 | 0 | 0 0 |
| May '60 | 35°32'N,62°58'W | 2950 | -8 | -4 | 0 X |
| May-Jun '60 | 35°15'N,62°42'W | 2600 | -9 | -4 | 0 X |
| May-Jun '60 | 35°11'N,62°11'W | 2640 | -4 | -4 | 0 0 |
| Jun '60 | 35°06'N,61°36'W | 3040 | 0 | 1 | 0 0 |
| Jun '66 | 37°08'N,68°40'W | 2440 | 1 | 0 | 0 0 |
| Jun-Aug '69 | 36°23'N,70°00'W | 4286 | 10 | -9 | X X |
| Mar '71 | 36°12'N,8°02'W | 510 | 0 | 0 | 0 0 |
| Mar '71 | 36°12'N,8°02'W | 924 | 4 | 3 | 0 0 |
| Mar '71 | 36°13'N,8°02'W | 760 | 3 | 2 | 0 0 |
| Mar '71 | 36°16'N,8°09'W | 1384 | 7 | -4 | X X |
| Mar '71 | 36°12'N,8°01'W | 1100 | 3 | 3 | 0 0 |

## 32°N

| DATE (Mo.-Yr.) | POSITION (Lat.-Long.) | DEPTH (m) | MEASURED (cm/sec) | CALCULATED (cm/sec) | CORRELATION CATEGORY |
|---|---|---|---|---|---|
| Feb '60 | 32°16'N,64°37'W | 570 | -1 | -3 | 0 0 |
| Feb '60 | 32°15'N,64°32'W | 805 | 4 | -1 | X X |
| Feb '60 | 32°17'N,64°34'W | 1200 | 3 | 0 | 0 0 |
| Feb '60 | 32°18'N,64°33'W | 1310 | 4 | 0 | 0 0 |
| Mar '60 | 32°13'N,64°49'W | 310 | -4 | -3 | 0 0 |
| Mar '60 | 32°24'N,64°59'W | 440 | 8 | -3 | X X |
| Apr '60 | 32°28'N,64°30'W | 630 | -12 | -2 | 0 X |
| Aug '61 | 31°57'N,65°11'W | 16 | -7 | -4 | 0 0 |
| Aug '61 | 31°57'N,65°11'W | 28 | -10 | -3 | 0 X |
| Aug '61 | 31°57'N,65°12'W | 10 | -36 | -4 | 0 X |
| Aug '61 | 31°57'N,65°12'W | 34 | -25 | -3 | 0 X |
| Aug '61 | 31°59'N,61°10'W | 16 | -27 | -4 | 0 X |
| Aug '61 | 31°59'N,61°10'W | 40 | -21 | -3 | 0 X |
| Jun-Jul '64 | 34°26'N,69°47'W | 5337 | 0 to 2 | 2 | 0 0 |
| Mar '67 | 31°55'N,15°06'W | 1520 | 2 | -1 | X X |
| May -- | 32°30'N,65°00'W | 0 | 44 | -4 | X X |
| May -- | 32°30'N,65°00'W | 50 | 26 | -3 | X X |
| May -- | 32°30'N,65°00'W | 100 | 15 | -3 | X X |
| May -- | 32°30'N,65°00'W | 200 | 11 | -3 | X X |
| May -- | 32°30'N,65°00'W | 300 | 7 | -3 | X X |
| May -- | 32°30'N,65°00'W | 400 | 7 | -3 | X X |
| May -- | 32°30'N,65°00'W | 600 | 7 | -2 | X X |
| May -- | 32°30'N,65°00'W | 800 | 13 | -1 | X X |
| May -- | 32°30'N,65°00'W | 1000 | -11 | 0 | 0 X |
| May -- | 32°30'N,65°00'W | 1400 | -4 | 1 | X X |
| May -- | 32°30'N,65°00'W | 1600 | 4 | 1 | 0 0 |
| May -- | 32°00'N,65°12'W | 12 | -21 | -4 | 0 X |
| May -- | 32°00'N,65°12'W | 38 | -18 | -3 | 0 X |

24°N (and 27°N)

| DATE (Mo.-Yr.) | POSITION (Lat.-Long.) | DEPTH (m) | MEASURED (cm/sec) | CALCULATED (cm/sec) | CORRELATION CATEGORY |
|---|---|---|---|---|---|
| Jun-Jul '65 | 25°31'N,72°33'W | 50 | 4 to 22 | 9 | 0 0 |
| | | 100 | 7 to 10 | 10 | 0 0 |
| | | 200 | 11 to 25 | 11 | 0 0 |
| | | 400 | 7 to 18 | 11 | 0 0 |
| | | 600 | 7 to 15 | 8 | 0 0 |
| | | 800 | 4 to 15 | 5 | 0 0 |
| | | 1200 | 4 to 15 | -1 | X X |
| | | 1500 | 4 to 15 | -2 | X X |
| | | 2000 | 4 to 11 | -2 | X X |
| | | 3000 | 4 to 7 | 0 | 0 0 |
| | | 4750 | 4 to 11 | 3 | 0 0 |
| Jan-Feb '66 | 25°31'N,72°33'W | 100 | -31 | 10 | X X |
| | | 200 | -21 | 11 | X X |
| | | 500 | -10 | 10 | X X |
| | | 2000 | -5 | -1 | 0 0 |
| | | 3200 | 10 | 1 | 0 X |
| | | 3900 | 10 | 2 | 0 X |
| | | 5380 | -4 | 3 | X X |
| Jun-Jul '66 | 25°31'N,72°33'W | 50 | 2 | 9 | 0 X |
| | | 100 | 10 | 10 | 0 0 |
| | | 200 | 15 | 11 | 0 0 |
| | | 600 | 11 | 8 | 0 0 |
| | | 1200 | 17 | -1 | X X |
| Jun-Jul '66 | 25°32'N,72°32'W | 400 | 6 | 11 | 0 0 |
| | | 800 | 13 | 5 | 0 X |
| | | 1500 | 3 | -2 | X X |
| | | 3000 | 16. | 0 | 0 X |
| Jun-Jul '66 | 25°31'N,72°33'W | 50 | -1 | 9 | X X |
| Jun '67 | 27°25'N,79°57'W | 0 | 129 | 103 | 0 0 |
| | 27°25'N,79°54'W | 0 | 158 to 171 | 135 | 0 0 |
| | 27°25'N,79°51'W | 0 | 157 to 190 | 155 | 0 0 |
| | 27°25'N,79°48'W | 0 | 157 to 194 | 155 | 0 0 |
| | 27°25'N,79°45'W | 0 | 153 | 155 | 0 0 |
| | 27°25'N,79°38'W | 0 | 149 | 202 | 0 0 |
| | 27°25'N,79°33'W | 0 | 96 | 89 | 0 0 |
| | 27°25'N,79°26'W | 0 | 62 to 93 | -23 | X X |
| | 27°25'N,79°21'W | 0 | 54 to 58 | 17 | 0 X |
| | 27°25'N,79°14'W | 0 | 30 to 45 | 12 | 0 X |
| | 27°25'N,79°08'W | 0 | 5 | 7 | 0 0 |

24°N (and 27°N) - Concluded

| DATE (Mo.-Yr.) | POSITION (Lat.-Long.) | DEPTH (m) | MEASURED (cm/sec) | CALCULATED (cm/sec) | CORRELATION CATEGORY |
|---|---|---|---|---|---|
| Jan-Apr '71 | 22°15'N,67°18'W | 5201 | -1 to -4 | -2 | 0 0 |
| Nov'71 - Jun '72 | 23°22'N,69°09'W | 5352 | 11 | 8 | 0 0 |
| Nov'71 - Jun '72 | 23°48'N,68°38'W | 5290 | -5 | 7 | X X |

16°N

| DATE (Mo.-Yr.) | POSITION (Lat.-Long.) | DEPTH (m) | MEASURED (cm/sec) | CALCULATED (cm/sec) | CORRELATION CATEGORY |
|---|---|---|---|---|---|
| Feb -- | 16°48'N,46°18'W | 0 | -12 | -14 | 0 0 |
| | | 15 | -16 | -14 | 0 0 |
| | | 50 | -15 | -13 | 0 0 |
| | | 100 | -13 | -11 | 0 0 |
| | | 300 | -9 | -4 | 0 X |
| | | 500 | -7 | -3 | 0 X |
| | | 800 | 0 | -2 | 0 0 |
| Feb -- | 16°48'N,46°18'W | 800 | -4 | -2 | 0 0 |

8°N

NONE

# APPENDIX C

## TABULATION OF ALL DIRECTLY MEASURED CURRENT DATA LOCATED

* Current data were discovered in many formats. The following parameters were used in standardizing the tabulation:

(1) latitude and longitude were rounded to the nearest whole minute in those cases where its accuracy had been recorded to include seconds.

(2) when neutrally buoyant floats or drogue measurements were made and a start and finish position were available, the mean latitude and mean longitude between the two points was recorded as the position.

(3) except where noted, durations given in hours were rounded to the nearest whole day above zero.

** Current data are presented in the following format:

DATE(mo. yr.) / POSITION / DEPTH / DURATION / SPEED / DIRECTION / SOURCE

*** Additional data, in a modified format, are presented in the latter part of this appendix.

<u>40°N</u>

1. JUN'55 / 41°08'N,41°36'W / 400m / 4d / 2.4 cm/sec / 300°T / SWALLOW,1955
2. JUN'55 / " / 900m / 3d / 5.7 cm/sec / 250°T / "
3. JUN'55 / 41°09'N,14°36'W / 630m / 3d / 2.2±0.2 cm/sec / 304±3°T / CASTON & SWALLOW,1969
4. JUN'55 / 41°08'N,14°35'W / 1100m / 1d / 8.6±1.2 cm/sec / 239±4°T / "
5. MAY-JUL'58 / 41°25'N,14°30'W / 1560±50m / 5d / 4.14±0.11 cm/sec / 137.4±1.6°T / SWALLOW & HAMON,1960
6. " / " / 2120±50m / 9d / 4.74±0.06 cm/sec / 145.9±0.8°T / "
7. " / " /2430±30m / 4d / 3.0 cm/sec / 208°T / "
8. " / " /2460±50m / 3d / 0.1 cm/sec / 180°T / "
9. " / " /2460±50m / 8d / 0.9 cm/sec / 236°T / "
10. " / " /2590±70m / 7d / 5.19±0.13 cm/sec / 252.6±1.4°T / "
11. " / " /2590±70m / 6d / 4.62±0.15 cm/sec / 255.0±3.3°T / "
12. " / " /2760±110m / 2d / 1.2 cm/sec / 187°T / "
13. " / " /2760±110m / 2d / 1.3 cm/sec / 290°T / "
14. " / " /2940±70m / 8d / 1.2 cm/sec / 156°T / "
15. " / " /2940±70m / 17d / 1.0 cm/sec / 233°T / "
16. " / " /3680±100m / 7d / 2.62±0.07 cm/sec / 145.4±1.4°T / "
17. " / " /4240±160m / 6d / 1.90±0.13 cm/sec / 141.5±3.7°T / "
18. FEB-APR'67 / 39°18'N,70°06'W / 106m / 44d / 2.39 cm/sec / SOUTH COMPONENT / TARBELL,1974
19. " / " / 511m / 45d / 3.36 cm/sec / " / "
20. " / " / 1013m / 47d / 1.97 cm/sec / " / "
21. " / " / 2028m / 27d / 2.14 cm/sec / " / "
22. " / 40°11'N,70°01'W / 49m / 6d / 1.02 cm/sec / NORTH COMPONENT / "

40°N (Continued)

23. FEB-APR'67 / 40°11'N,70°01'W / 67m / 6d / 2.96 cm/sec / NORTH COMPONENT / TARBELL,1974
24. " / 39°18'N,69°55'W / 207m / 42d / 3.87 cm/sec / " / "
25. " / " / 509m / 22d / 1.07 cm/sec / " / "
26. " / " / 509m / 16d / 2.44 cm/sec / " / "
27. JUN-AUG'67 / 39°18'N,70°03'W / 57m / 27d / 2.08 cm/sec / " / "
28. " / " / 428m / 44d / 2.08 cm/sec / " / "
29. " / " / 930m / 48d / 1.21 cm/sec / " / "
30. " / " / 1990m / 45d / 0.55 cm/sec / " / "
31. JUL'67 / 39°19'N,69°58'W / 488m / 5d / 2.76 cm/sec / " / "
32. " / 39°17'N,69°57'W / 492m / 8d / 5.65 cm/sec / " / "
33. " / " / 503m / 8d / 5.46 cm/sec / " / "
34. " / 39°18'N,69°58'W / 511m / 7d / 2.46 cm/sec / " / "
35. OCT'67 / 39°21'N,70°03'W / 97m / 7d / 0.39 cm/sec / " / "
36. " / " / 101m / 7d / 2.58 cm/sec / " / "
37. APR-MAY'68 / 39°11'N,69°55'W / 2578m / 23d / 0.06 cm/sec / SOUTH COMPONENT / CHAUSSE & TARBELL,1974
38. " / 39°10'N,69°52'W / 2558m / 23d / 1.14 cm/sec / NORTH COMPONENT / "
39. JUL'68 / 39°33'N,67°12'W / 3693m / 11d / 8-13 cm/sec / SSW / ZIMMERMAN,1971
40. " / 37°41'N,65°15'W / 5065m / 7d / 5-14 cm/sec / NE / "
41. AUG'68 / 39°09'N,70°06'W / 10m / 7d / 4.86 cm/sec / NORTH COMPONENT / CHAUSSE & TARBELL,1974
42. " / " / 20m / " / 3.92 cm/sec / " / "
43. " / " / 40m / " / 4.20 cm/sec / " / "
44. AUG-OCT'68 / 39°10'N,70°04'W / 14m / 40d / 8.28 cm/sec / " / "

<u>40°N</u> (Continued)

45. AUG-OCT'68 / 39°10'N,70°04'W / 54m / 40d / 5.61 cm/sec / NORTH COMPONENT / CHAUSSE & TARBELL,1974
46. " / " / 105m / " / 0.80 cm/sec / " / "
47. OCT-NOV'68 / 39°10'N,70°03'W / 12m / 57d / 4.42 cm/sec / " / "
48. " / " / 104m / " / 2.18 cm/sec / " / "
49. NOV'68 / 39°11'N,69°14'W / 2900m / 25d / 8-13 cm/sec / WSW / ZIMMERMAN,1971
50. DEC'68 / 39°10'N,70°05'W / 492m / 7d / 2.99 cm/sec / NORTH COMPONENT / CHAUSSE & TARBELL,1974
51. " / " / 531m / 7d / 2.99 cm/sec / " / "
52. DEC'68-APR'69 / 39°10'N,70°04'W / 12m / 9.29 cm/sec / " / "
53. " / " / 54m / 3.63 cm/sec / " / "
54. " / " / 106m / 1.15 cm/sec / SOUTH COMPONENT / "
55. JUN'69 / 40°34'N,65°31'W / 3638m / 7d / 5-20 cm/sec / SE / ZIMMERMAN,1971
56. " / 40°48'N,64°57'W / 4394m / 6d / 5-20 cm/sec / SW / "
57. " / 39°41'N,63°48'W / 4894m /7d / 8-13 cm/sec / SW / "
58. JUN-AUG'69 / 39°09'N,70°00'W / 108m / 60d / 10 cm/sec / NORTH COMPONENT / SCHMITZ et al.,1970
59. " / 39°06'N,70°00'W / 2585m / 125d / 10 cm/sec / " / "
60. JUN'70 / 40°30'N,49°30'W / 3780m / 13d / 7.6 cm/sec / 305°T / CLARKE & REINIGER,1973
61. " / 39°30'N,49°30'W / 5256m / 11d / 12.4 cm/sec / 295°T / "
62. " / 38°30'N,49°30'W / 5171m / 9d / 15.6 cm/sec / 043°T / "
63. " / " / 5271m / 9d / 15.5 cm/sec / 041°T / "
64. JUN-AUG'70 / 39°35'N,69°56'W / 12m / 51d / 17.85 cm/sec / NORTH COMPONENT / POLLARD & TARBELL,1975
65. " / " / 52m / " / 7.62 cm/sec / " / "
66. " / " / 72m / " / 5.40 cm/sec / " / "

40°N (Continued)

67. JUN-AUG'70 / 39°35'N,69°56'W / 2167m / 51d / 1.28 cm/sec / NORTH COMPONENT / POLLARD & TARBELL,1975

68. " / 39°08'N,70°02'W / 12m / " / 0.96 cm/sec / SOUTH COMPONENT / "

69. " / " / 32m / " / 2.66 cm/sec / NORTH COMPONENT / "

70. " / " / 52m / " / 0.34 cm/sec / SOUTH COMPONENT / "

71. " / " / 72m / " / 0.76 cm/sec / NORTH COMPONENT / "

72. " / " / 2545m / " / 0.14 cm/sec / SOUTH COMPONENT / "

73. " / 39°08'N,70°35'W / 12m / " / 6.26 cm/sec / NORTH COMPONENT / "

74. " / " / 32m / " / 4.10 cm/sec / SOUTH COMPONENT / "

75. " / " / 52m / " / 1.39 cm/sec / SOUTH COMPONENT / "

76. " / " / 72m / " / 1.88 cm/sec / " / "

77. " / " / 2620m / " / 0.86 cm/sec / " / "

<u>36°N</u>

1. OCT'55 / 35°25'N,11°25'W / 1150m / 3d / 9.3±0.1 cm/sec / 022±0.6°T / CASTON & SWALLOW,1969
2. AUG'56 / 36°39'N,17°19'W / 2900m / 2d / 0.8±0.1 cm/sec / 166±10°T / CASTON & SWALLOW,1969
3. NOV'58 / 36°27'N,8°54'W / 1080m / 2d / 21.5±3.1 cm/sec / 256±2°T / CASTON & SWALLOW,1970a
4. NOV'58 / 35°47'N,8°40'W / 1260m / 2d / 2.3±0.3 cm/sec / 131±3°T / CASTON & SWALLOW,1970a
5. NOV'58 / 36°31'N,8°53'W / 1290m / 5 hrs / 22.0 cm/sec / 252°T / CASTON & SWALLOW,1970a
6. JUL'59 / 37°30'N,70°50'W / 1945±595m / 2d / 21.5±1.0 cm/sec / 248°T / VOLKMAN,1962
7. JUL'59 / 37°30'N,70°50'W / 3200±980m / 1d / 18.4±1.8 cm/sec / 230°T / "
8. JUL'59 / 38°50'N,70°50'W / 1900±535m / 1d / 11.4±1.1 cm/sec / 263°T-213°T / "
9. JUL'59 / 37°30'N,70°50'W / 10m / 1d / 13.0±3 cm/sec / 275°T / "
10. " / " / 200m / 1d / 15.0±2 cm/sec / 250°T / "
11. " / " / 2000m / 2d / 11.5±1 cm/sec / 249°T / "
12. " / " / 2000m / 5d / 18.0±1 cm/sec / 247°T / "
13. " / " / 1000m / 1d / 16.0±2 cm/sec / 257°T / "
14. " / " / 3000m / 5d / 16.6±1 cm/sec / 248°T / "
15. JUL'59 / 38°50'N,70°50'W / 2000m / 2d / 10.2±1 cm/sec / 256°T / "
16. JUL'59 / " / 2700m / 1d / 10.4±1 cm/sec / 262°T / "
17. MAY'60 / 35°32'N,62°58'W / 2950m / 5d / 8.56 cm/sec / SOUTH COMPONENT / CASTON & SWALLOW,1970d
18. MAY-JUN'60 / 35°15'N,62°42'W / 2600m / 7d / 8.83 cm/sec / SOUTH COMPONENT / "
19. MAY-JUN'60 / 35°11'N,62°11'W / 2640m / 6d / 4.10 cm/sec / SOUTH COMPONENT / "
20. JUN'60 / 35°06'N,61°36'W / 3040m / 2d / 0.18 cm/sec / NORTH COMPONENT / "
21. JUL'60 / 36°50'N,68°30'W / 1330±540m / 1d / 23.5±0.3 cm/sec / 113°T / VOLKMAN,1962
22. " / 36°47'N,68°30'W / 2160±945m / 1d / 19.2±0.8 cm/sec / 106°T / "

36°N (Continued)

23. JUL'60 / 38°54'N,68°30'W / 1850±610m / 2d / 11.8±0.5 cm/sec / 294°T / VOLKMAN,1962
24. " / 39°18'N,68°30'W / 1910±680m / 4d / 7.4±0.5 cm/sec / 326°T-089°T / "
25. " / 38°00'N,68°30'W / 2120±640m / 1d / 10.0±0.4 cm/sec / 130°T / "
26. " / 38°00'N,68°30'W / 2460±585m / 1d /6.5±0.8 cm/sec / 125°T / "
27. JUN-JUL'64 / 36°04'N,73°13'W / 3584m / 1d / 7.5-14.0 cm/sec / 027°T-040°T / KNAUSS,1965
28. " / 34°24'N,69°47'W / 5337m / 2d / 0.0-2.0 cm/sec / 019°T-072°T / "
29. JUN'66 / 37°52'N,69°20'W / 2480±80m / 2d / 10.6±0.2 cm/sec / 057±1°T / WARREN & VOLKMAN,1968
30. " / 37°45'N,69°10'W / 2520±90m / 2d / 11.0±1.2 cm/sec / 045±13°T / "
31. " / 37°35'N,69°05'W / 2620±130m / 3d / 4.6±0.5 cm/sec / 026±11°T / "
32. " / 37°25'N,69°03'W / 2430±140m / 3d / 5.6±0.4 cm/sec / 093±5°T / "
33. " / 37°15'N,68°50'W / 2400±32m / 3d / 6.4±0.3 cm/sec / 075±5°T / "
34. " / 37°08'N,68°40'W / 2440±90m / 2d / 5.7±1.0 cm/sec / 084±25°T / "
35. " / 36°56'N,68°32'W / 2400±92m / 2d / 1.6±0.7 cm/sec / 025±32°T / "
36. " / 36°50'N,68°26'W / 2580±30m / 2d / 3.8±1.3 cm/sec / 305±8°T / "
37. " / 36°45'N,68°19'W / 2440±45m / 7d / 2.1±0.2 cm/sec / 006±5°T / "
38. JUN-AUG'69 / 37°20'N,70°00'W / 4081m / 17d / 10.0 cm/sec / NORTH COMPONENT / SCHMITZ et al.,1970
39. " / 36°43'N,70°00'W / 4226m / 60d / 10.0 cm/sec / " / "
40. " / 36°23'N,70°00'W / 4286m / 60d / 10.0 cm/sec / " / "
41. MAR'71 / 36°12'N,8°02'W / 510m / 20d / 0.64 cm/sec / 313°T / PARKER,1976
42. " / " / 924m / " / 4.26 cm/sec / 342°T / "
43. " / " / 1199m / " / 7.30 cm/sec / 319°T / "
44. " / " / 1388m / " / 1.37 cm/sec / 306°T / "
45. " / " / 1398m / " / 0.85 cm/sec / 311°T / "
46. " / 36°13'N,8°02'W / 760m / " / 2.93 cm/sec / 346°T / "

36°N (Continued)

47. MAR'71 / 36°13'N,8°02'W / 1077m / 20d / 6.63 cm/sec / 331°T / PARKER,1976

48. " / " / 1303m / " / 4.2 cm/sec / 320°T / "

49. " / " / 1402m / " / 1.09 cm/sec / 321°T / "

50. " / " / 1480m / " / 1.01 cm/sec / 340°T / "

51. " / 36°16'N,8°09'W / 1384m / 11d / 9.19 cm/sec / 322°T / "

52. " / 36°12'N,8°01'W / 1100m(appr.) / brief / 4.5 cm/sec / NORTHWEST / PARKER,1976

53. MAY'71 / 35°05'N,75°02'W / 1265m / 18d / 0.3 cm/sec / 026°T / BETZER et al.,1973

54. " / 34°51'N,79°49'W / 2810m / 5d / 12.6 cm/sec / 266°T / "

55. " / 34°32'N,74°30'W / 3220m / 18d / 6.8 cm/sec / 228°T / "

56. " / 34°06'N,74°01'W / 4145m / 22d / 9.1 cm/sec / 253°T / "

57. MAY-JUL'71 / 34°17'N,74°13'W / 3720m / 28d / 0.8 cm/sec / 169°T / "

58. " / 34°59'N,74°59'W / 2575m / 54d / 10.9 cm/sec / 228°T / "

## 32°N

1. NOV'55 / 30°13'N,15°59'W / 1980m / 2d / 2.3±0.1 cm/sec / 037±1.7°T / CASTON & SWALLOW,1969
2. " / 30°11'N,16°00'W / 1870m / 2d / 1.6±0.2 cm/sec / 175±11°T / "
3. MAR'57 / 32°30'N,75°21'W / 2070m / 5d / 1.7±0.7 cm/sec / 331±21°T / "
4. JUN'59 / 32°09'N,67°12'W / 1816m / 8d / 2.7±0.4 cm/sec / 221±8°T / CASTON & SWALLOW,1970b
5. JUN-JUL'59 / 31°51'N,67°30'W / 1908m / 18d / 1.5±0.3 cm/sec / 254±2.5°T / "
6. " / " / " / 20d / 6.5 cm/sec / 215°T / "
7. " / 31°59'N,67°12'W / 2791m / 22d / 2.3±0.2 cm/sec / 192±3°T / "
8. JUL'59 / 32°09'N,67°09'W / 3169m / 3d / 4.3±0.6 cm/sec / 136±5°T / "
9. " / 32°06'N,67°07'W / 2916m / 6d / 4.5±0.4 cm/sec / 158±11°T / "
10. " / 31°56'N,67°21'W / 3533m / 5d / 12.3±0.3 cm/sec / 221±1°T / "
11. AUG'59 / 31°05'N,68°32'W / 2159m / 9d / 8.8±0.3 cm/sec / 253±1.1°T / "
12. " / 31°18'N,68°33'W / 2306m / 8d / 12.4±0.6 cm/sec / 253±3°T / "
13. " / 32°02'N,67°27'W / 1906m / 1d / 7.5±0.0 cm/sec / 274°T / "
14. AUG-SEP'59 / 31°42'N,68°24'W / 2148m / 7d / 12.2±0.5 cm/sec / 322±1.3°T / "
15. " / 32°22'N,68°17'W / 1900m / 6d / 2.8±0.5 cm/sec / 006±1.3°T / "
16. SEP'59 / 31°55'N,66°52'W / 1836m / 4d / 9.9±0.8 cm/sec / 131±2.5°T / "
17. " / 31°55'N,66°54'W / 1654m / 4d / 10.0±0.8 cm/sec / 132±3°T / "
18. " / 31°56'N,66°53'W / 1754m / 4d / 10.6±0.8 cm/sec / 129±2°T / "
19. OCT'59 / 31°09'N,68°10'W / 2158m / 10d / 1.5±0.5 cm/sec / 037±12°T / "
20. " / 31°11'N,68°30'W / 2006m / 2d / 8.7±0.2 cm/sec / 229±1.5°T / "
21. " / 31°08'N,69°23'W / 1883m / 8d / 9.4±0.4 cm/sec / 257±0.6°T / "
22. " / 31°23'N,69°07'W / 2114m / 3d / 8.8±0.9 cm/sec / 186±0.8°T / "

## 32°N (Continued)

23. OCT'59 / 30°55'N,68°59'W / 1954m / 2d / 5.3±0.4 cm/sec / 204±2°T / CASTON & SWALLOW,1970b

24. NOV'59 / 30°59'N,69°37'W / 1100m / <1d / 46.1 cm/sec / 157°T / "

25. " / 30°50'N,70°04'W / 1220m / 1d / 48.8±0.8 cm/sec / 090±1.4°T / "

26. " / 30°45'N,70°02'W / 1962m / 8d / 7.6±0.2 cm/sec / 194±1.3°T / "

27. " / 30°29'N,70°00'W / 1855m / 7d / 5.7±0.3 cm/sec / 217±1.3°T / "

28. " / 30°47'N,70°41'W / 2013m / 7d / 2.7±0.2 cm/sec / 073±6.9°T / "

29. " / 30°49'N,69°55'W / 640m / <1d / 52.1±0.8 cm/sec / 171±2°T / "

30. " / 32°03'N,66°18'W / 2296m / 1d / 1.4±1 cm/sec / 193±50°T / "

31. " / 30°37'N,69°55'W / 4350m / 2d / 7.2±0.5 cm/sec / 168±3°T / "

32. " / 30°41'N,69°34'W / 1890m / 2d / 5.6±0.6 cm/sec / 188±8°T / "

33. " / 30°46'N,65°35'W / 2290m / 4d / 3.6±0.8 cm/sec / 305±1.9°T / "

34. NOV-DEC'59 / 30°37'N,65°00'W / 2000m / 3d / 1.4±0.3 cm/sec / 299±13°T / CASTON & SWALLOW,1970c

35. " / 30°43'N,65°32'W / 2510m / 1d / 4.3 cm/sec / 180°T / "

36. " / 30°57'N,64°37'W / 2000m / 2d / 1.0 cm/sec / 248°T / "

37. DEC'59 / 30°46'N,65°35'W / 2290m / 2d / 8.5 cm/sec / 306°T / "

38. " / 30°46'N,65°27'W / 2757m / 4d / 2.9±0.4 cm/sec / 311±2°T / "

39. " / 30°31'N,64°37'W / 1065m / 3d / 13.9±1.1 cm/sec / 228±1.7°T / "

40. " / 30°36'N,64°32'W / 4738m / 3d / 2.9±0.2 cm/sec / 283±6°T / "

41. " / 31°05'N,69°08'W / 1920m / 3d / 3.8±0.3 cm/sec / 131±4°T / "

42. " / 31°25'N,69°05'W / 1960m / 2d / 4.7±0.8 cm/sec / 095±6°T / "

43. " / 31°15'N,69°26'W / 1720m / 2d / 5.1±0.4 cm/sec / 079±6°T / "

44. FEB'60 / 32°16'N,64°37'W / 570m / 3d / 2.2±0.3 cm/sec / 231±6°T / CASTON & SWALLOW,1970d

32°N (Continued)

45. FEB'60 / 32°15'N,64°32'W / 805m / 2d / 5.3±0.5 cm/sec / 037±3°T / CASTON & SWALLOW,1970d

46. " / 32°17'N,64°34'W / 1200m / 4d / 5.4±0.7 cm/sec / 062±8°T / "

47. " / 32°18'N,64°33'W / 1310m / 4d / 8.1±0.7 cm/sec / 058±6°T / "

48. " / 32°19'N,64°33'W / 1290m / 4d / 7.2±0.6 cm/sec / 045±11°T / "

49. MAR'60 / 32°13'N,64°49'W / 310m / 3d / 8.9±0.5 cm/sec / 246±1.9°T / "

50. MAR'60 / 32°24'N,64°59'W / 440m / 2d / 9.4±0.3 cm/sec / 032±0.3°T / "

51. APR'60 / 32°28'N,64°30'W / 630m / 1d / 18.4±1.0 cm/sec / 132±1.1°T / "

52. " / 31°43'N,67°32'W / 1782m / 4d / 8.7±0.2 cm/sec / 195±2°T / "

53. " / 31°47'N,67°36'W / 3270m / 3d / 9.8±0.6 cm/sec / 198±4°T / "

54. " / 31°43'N,67°30'W / 3940m / 4d / 12.1±0.3 cm/sec / 186±3°T / "

55. " / 31°41'N,67°30'W / 4710m / 1d / 10.4±1.5 cm/sec / 194±13°T / "

56. MAY'60 / 31°33'N,67°19'W / 2000m / 1d / 2.3 cm/sec / 053°T / "

57. " / 31°54'N,67°18'W / 1960m / 1d / 2.9±2.9 cm/sec / 300±27°T / "

58. " / 31°37'N,67°25'W / 1880m / 5d / 0.9±0.2 cm/sec / 018±13°T / "

59. " / 31°51'N,67°25'W / 1890m / 4d / 0.5±0.2 cm/sec / 069±27°T / "

60. " / 31°50'N,67°36'W / 1780m / 4d / 6.5±1.1 cm/sec / 158±23°T / "

61. " / 35°32'N,62°58'W / 2950m / 5d / 9.0±0.4 cm/sec / 198±2°T / "

62. MAY-JUN'60 / 32°15'N,62°42'W / 2600m / 7d / 10.0±0.3 cm/sec / 208±2°T / "

63. " / 35°11'N,62°11'W / 2640m / 6d / 5.9±0.5 cm/sec / 226±3°T / "

64. JUN'60 / 35°06'N,61°36'W / 3040m / 2d / 1.5±1.8 cm/sec / 083±46°T / "

65. " / 31°49'N,67°27'W / 1780m / 9d / 5.1±0.1 cm/sec / 321±7°T / CASTON & SWALLOW,1971

66. " / 31°58'N,67°21'W / 1840m / 3d / 3.8±0.1 cm/sec / 342±3°T / "

32°N (Continued)

67. JUN'60 / 31°58'N,67°42'W / 1990m / 8d / 6.2±0.1 cm/sec / 327±0.4°T / CASTON & SWALLOW,1971
68. " / 31°52'N,67°23'W / 3690m / 7d / 3.9±0.5 cm/sec / 351±0.8°T / "
69. " / 31°40'N,67°42'W / 1680m / 1d / 7.0±0.3 cm/sec / 318±2°T / "
70. JUL'60 / 34°13'N,62°11'W / 1950m / 11d / 17.8±0.3 cm/sec / 350±1°T / "
71. " / 33°41'N,61°45'W / 2058m / 5d / 8.5±0.2 cm/sec / 352±1.8°T / "
72. " / 33°40'N,62°15'W / 2250m / 2d / 5.9±1.7 cm/sec / 359±8°T / "
73. " / 33°46'N,62°08'W / 1950m / 1d / 16.3 cm/sec / 349°T / "
74. " / 34°34'N,62°09'W / 4360m / 7d / 25.1±0.9 cm/sec / 328±1.2°T / "
75. " / 34°37'N,62°13'W / 3825m / 2d / 42.4±0.4 cm/sec / 346±0.5°T / "
76. JUL-AUG'60 / 31°20'N,67°30'W / 1820m / 10d / 9.0±0.2 cm/sec / 217±0.2°T / "
77. " / 31°13'N,67°28'W / 3650m / 10d / 10.7±0.2 cm/sec / 206±0.4°T / "
78. " / 31°28'N,67°48'W / 2370m / 10d / 4.4±0.2 cm/sec / 252±3°T / "
79. " / 31°30'N,67°45'W / 1909m / 8d / 7.5±0.3 cm/sec / 240±1.6°T / "
80. AUG'60 / 31°58'N,67°29'W/ 2220m / 6d / 7.0±0.1 cm/sec / 322±0.6°T / "
81. " / 31°55'N,67°34'W / 2100m / 5d / 7.2±0.1 cm/sec / 310±0.2°T / "
82. " / 31°54'N,67°36'W / 1620m / 7d / 7.5±0.1 cm/sec / 306±0.3°T / "
83. " / 31°51'N,67°34'W / 3615m / 5d / 12.5±0.2 cm/sec / 337±0.6°T / "
84. " / 32°00'N,67°32'W / 4070m / 6d / 13.5±0.1 cm/sec / 343±0.8°T / "
85. " / 31°58'N,67°37'W / 4130m / 6d / 11.9±0.2 cm/sec / 339±1.2°T / "
86. AUG'61 / 31°57'N,65°11'W / 16m / 2d / 0.2 KTS / 136°T / PEDRICK,1962
87. " / " / 22m / " / " / 144°T / "
88. " / " / 28m / " / " / 160°T / "

32°N (Continued)

89. AUG'61 / 31°57'N,65°12'W / 4m / 2d / 0.7 KTS / 176°T / PEDRICK,1962
90. " / " / 10m / " / " / 183°T / "
91. " / " / 16m / " / " / 181°T / "
92. " / " / 22m / " / " / 184°T / "
93. " / " / 28m / " / 0.5 KTS / 187°T / "
94. " / " / 34m / " / " / 187°T / "
95. " / / 40m / " / 0.4 KTS / 183°T / "
96. " / 31°59'N,65°10'W / 4m / " / 0.7 KTS / 157°T / "
97. " / " / 10m / " / 0.6 KTS / 146°T / "
98. " / " / 16m / " / " / 150°T / "
99. " / " / 22m / " / " / 154°T / "
100. " / " / 28m / " / 0.5 KTS / 145°T / "
101. " / " / 34m / " / " / 153°T / "
102. " / " / 40m / " / " / 146°T / "
103. " / " / 46m / " / 0.4 KTS / 138°T / "
104. OCT'62 / 30°06'N,65°03'W / 50m / 5d / 7.0 cm/sec / 044°T / DAY & WEBSTER,1965
105. OCT'62-JAN'63 / 28°07'N,65°02'W / 50m / 85d / 7.0 cm/sec / 329°T / "
106. " / " / 100m / 110d / 9.0 cm/sec / 346°T / "
107. JUN-JUL'64 / 32°05'N,68°12'W / 5182 / 1d / 10-15 cm/sec / 114°T-133°T / KNAUSS,1965
108. " / 32°11'N,68°13'W / 5192m / 1d / 14-21 cm/sec / 119°T-139°T / "
109. MAR'66 / 31°55'N,15°06'W / 1520m / 2d / 2.4±0.2 cm/sec / 357±3°T / CASTON & SWALLOW,1973
110. " / 31°57'N,15°03'W / 1313m / 2d / 3.4±0.4 cm/sec / 013±4°T / "

32°N (Continued)

111. MAR'66 / 34°39'N,19°27'W / 5138m / 5d / 0.4±0.2 cm/sec / 086±35°T / CASTON & SWALLOW,1973

112. " / 34°49'N,19°40'W / 876m / 3d / 6.6±0.5 cm/sec / 142±3°T / "

113. " / 34°51'N,19°34'W / 930m / 3d / 8.5±0.4 cm/sec / 136±2°T / "

114. " / 34°47'N,19°37'W / 995m / 3d / 5.1±0.1 cm/sec / 154±3°T / "

115. FEB-APR'67 / 30°03'N,70°02'W / 10m / 55d / 8.21 cm/sec / NORTH COMPONENT / TARBELL,1974

<u>24°N</u>

1. JAN-FEB'65 / 25°31'N,72°33'W / 100m / 16d / 0.6 KTS / S / BOISVERT,1967
2. " / " / 200m / " / 0.4 KTS / S / "
3. " / " / 500m / " / 0.2 KTS / SSE / "
4. " / " / 1000-3000m / 16d / 0.1 KTS / S / BOISVERT,1967
5. " / " / 3200m / " / 0.2 KTS / NNE / "
6. " / " / 3900m / " / " / " / "
7. " / " / 5380m / " / " / ESE / "
8. JUN-JUL'65 / " / 50m / 15d / 0.1-0.6 KTS / NW / "
9. " / " / 100m / " / 0.2-0.8 KTS / NW / "
10. " / " / 200m / " / 0.3-0.7 KTS / NW / "
11. " / " / 400m / " / 0.2-0.5 KTS / NW / "
12. " / " / 600m / " / 0.2-0.4 KTS / NW / "
13. " / " / 800m / " / 0.1-0.4 KTS / NNW / "
14. " / " / 1200m / " / 0.1-0.4 KTS / N / "
15. " / " / 1500m / " / 0.1-0.4 KTS / NNE / "
16. " / " / 2000m / " / 0.1-0.3 KTS / NNE / "
17. " / " / 3000m / " / 0.1-0.2 KTS / NE / "
18. " / " / 4750m / " / 0.1-0.3 KTS / WNW / "
19. JUN-JUL'65 / 25°31'N,72°33'W / 50m / 17d / 0.07 KTS / 310°T / BURNS & BANCHERO,1966
20. " / " / 100m / " / 0.50 KTS / 292°T / "
21. " / " / 200m / " / 0.49 KTS / 306°T / "
22. " / " / 600m / " / 0.34 KTS / 310°T / "
23. " / " / 1200m / " / 0.33 KTS / 357°T / "

24°N (Continued)

24. JUN-JUL'65 / 25°32'N,72°32'W / 400m / 17d / 0.39 KTS / 286°T / BURNS & BANCHERO,1966
25. " / " / 800m / " / 0.27 KTS / 337°T / "
26. " / " / 1500m / " / 0.05 KTS / 352°T / "
27. " / " / 3000m / " / 0.52 KTS / 306°T / "
28. " / 25°30'N,72°33'W / 50m / " / 0.24 KTS / 264°T / "
29. " / " / 100m / " / 0.45 KTS / 290°T / "
30. " / " / 200m / " / 0.47 KTS / 032°T / "
31. " / " / 400m / " / 0.35 KTS / 329°T / "
32. MAR'67 / 26°50'N,77°02'W / 10m / 13d / 0.63 KTS / NW / COSTIN,1968
33. " / " / 30m / " / 0.89 KTS / NW / "
34. " / " / 60m / " / 0.43 KTS / NW / "
35. " / " / 80m / " / 0.49 KTS / NW / "
36. " / " / 30m / 7 hrs / 1.40 KTS / NW / "
37. " / " / 30m / " / 1.55 KTS / NW / "
38. " / " / 60m / " / 0.41 KTS / " / "
39. " / " / 225m / " / 1.00 KTS / " / "
40. " / " / 455m / " / 1.02 KTS / " / "
41. " / " / 750m / " / 1.10 KTS / " / "
42. JUN'67 / 27°25'N,79°57'W / 0m / 5 min / 129 cm/sec / N / CHEW et al.,1971
43. " / 27°25'N,79°54'W / " / " / 158-171 cm/sec / N / "
44. " / 27°25'N,79°51'W / " / " / 157-190 cm/sec / " / "
45. " / 27°25'N,79°48'W / " / " / 157-194 cm/sec / " / "

<u>24°N</u> (Continued)

46. JUN'67 / 27°25'N,79°45'W / 0m / 5 min / 153 cm/sec / N / CHEW et al.,1971
47. " / 27°25'N,79°38'W / " / " / 149 cm/sec / " / "
48. " / 27°25'N,79°33'W / " / " / 95-96 cm/sec / N / "
49. " / 27°25'N,79°26'W / " / " / 62-93 cm/sec / " / "
50. " / 27°25'N,79°21'W / " / " / 54-58 cm/sec / " / "
51. " / 27°25'N,79°14'W / " / " / 30-45 cm/sec / " / "
52. " / 27°25'N,79°08'W / " / " / 5 cm/sec / " / "
53. JAN-APR'71 / 22°15'N,67°18'W / 5201m / 88d / 2-10 cm/sec / ESE / TUCHOLKE et al.,1973
54. JAN-MAY'71 / 22°48'N,66°29'W / 5616m / 122d / 2-12 cm/sec / WNW / "
55. OCT'71-FEB'72 / 28°00'N,70°00'W / 816m / 96d / 0.7 cm/sec / SOUTH COMPONENT / GOULD et al.,1974
56. " / " / 1518m / " / 0.2 cm/sec / NORTH COMPONENT / "
57. " / " / 1620m / " / 0.8 cm/sec / " / "
58. " / " / 4202m / " / 0.7 cm/sec / " / "
59. " / 28°00'N,70°21'W / 514m / 99d / 0.6 cm/sec / " / "
60. " / " / 1516m / 97d / 1.7 cm/sec / SOUTH COMPONENT / "
61. " / " / 4001m / 99d / 0.0 cm/sec / NORTH COMPONENT / "
62. " / 27°49'N,70°09'W / 1503m / 98d / 0.1 cm/sec / SOUTH COMPONENT / "
63. " / 28°02'N,70°07'W / 1522m / " / 0.4 cm/sec / NORTH COMPONENT / "
64. " / " / 4028m / " / 0.1 cm/sec / SOUTH COMPONENT / "
65. " / 28°21'N,69°42'W / 1504m / " / 1.6 cm/sec / " / "
66. " / " / 4008m / " / 1.4 cm/sec / " / "
67. OCT'71-JAN'72 / 29°50'N,70°22'W / 3936m / 65d / 0.1 cm/sec / " / "

<u>24°N</u> (Continued)

68. NOV'71-JUN'72 / 23°22'N,69°08'W / 5352m / 169d / 15 cm/sec / NW / TUCHOLKE et al.,1973
69. " / 23°48'N,68°38'W / 5290m / 166d / 13 cm/sec / ESE / "
70. FEB-MAY'72 / 28°09'N,68°37'W / 1519m / 105d / 0.3 cm/sec / NORTH COMPONENT / GOULD et al.,1974
71. " / " / 4074m / 75d / 2.0 cm/sec / " / "
72. " / " / 5131m / 105d / 0.6 cm/sec / SOUTH COMPONENT / "
73. MAR-MAY'72 / 28°10'N,68°35'W / 3975m / 62d / 2.6 cm/sec / " / "
74. " / " / 5119m / 62d / 2.6 cm/sec / " / "
75. " / 28°20'N,68°25'W / 3995m / 63d / 0.8 cm/sec / " / "
76. " / 28°11'N,68°24'W / 3990m / 37d / 0.3 cm/sec / NORTH COMPONENT / "
77. " / 28°10'N,68°12'W / 3970m / 63d / 0.6 cm/sec / SOUTH COMPONENT / "
78. MAY-NOV'72 / 28°54'N,69°41'W / 4191m / 149d / 3.9 cm/sec / NORTH COMPONENT / "
79. " / 28°00'N,70°39'W / 4181m / 148d / 0.9 cm/sec / SOUTH COMPONENT / "
80. " / 27°34'N,69°42'W / 4207m / 147d / 1.7 cm/sec / NORTH COMPONENT / "
81. " / 28°01'N,69°38'W / 4208m / 151d / 1.3 cm/sec / " / "
82. APR'73 / 28°00'N,70°03'W / 590m / 6d / 11.2 cm/sec / 047°T / CASTON et al.,1974a
83. " / " / 1567m / 3d / 1.4 cm/sec / 287°T / "
84. " / " / 2900m / 34d / 1.4 cm/sec / 308°T / "
85. " / " / 1620m / 16d / 1.6 cm/sec / 284°T / "
86. " / " / 3700m / 20d / 2.4 cm/sec / 314°T / "
87. " / 28°03'N,69°51'W / 1650m / 18d / 2.9 cm/sec / 253°T / "
88. " / " / 2870m / 5d / 2.1 cm/sec / 244°T / "
89. " / " / 3820m / 15d / 2.9 cm/sec / 214°T / "
90. " / " / 550m / 6d / 5.8 cm/sec / 053°T / "

24°N (Continued)

91. APR'73 / 28°03'N,69°51'W / 2810m / 14d / 3.0 cm/sec / 244°T / CASTON et al.,1974a
92. " / 28°00'N,70°10'W / 1620m / 14d / 1.4 cm/sec / 320°T / "
93. " / " / 2920m / 17d / 2.6 cm/sec / 323°T / "
94. " / " / 3750m / 18d / 2.9 cm/sec / 330°T / "
95. " / 27°58'N,70°13'W / 1595m / 16d / 1.3 cm/sec / 317°T / "
96. " / " / 2830m / 17d / 2.8 cm/sec / 327°T / "
97. " / " / 3690m / 4d / 3.3 cm/sec / 323°T / "
98. " / " / 3810m / 17d / 3.4 cm/sec / 336°T / "
99. " / 27°50'N,70°25'W / 530m / 7d / 11.4 cm/sec / 041°T / "
100. " / " / 575m / 6d / 8.3 cm/sec / 052°T / "
101. " / " / 580m / 6d / 5.0 cm/sec / 339°T / "
102. " / " / 590m / 11d / 8.3 cm/sec / 046°T / "
103. " / " / 625m / 17d / 5.7 cm/sec / 018°T / "
104. " / " / 895m / 8d / 3.8 cm/sec / 027°T / "
105. MAY'73 / 28°02'N,68°31'W / 1530m / 15d / 1.2 cm/sec / 272°T / CASTON et al.,1974b
106. " / 28°00'N,68°04'W / 3750m / 15d / 1.7 cm/sec / 089°T / "
107. " / 28°01'N,67°38'W / 2830m / 15d / 7.2 cm/sec / 086°T / "
108. " / 28°11'N,68°20'W / 4100m / 11d / 3.1 cm/sec / 071°T / "
109. " / 28°28'N,68°31'W / 580m / 9d / 6.7 cm/sec / 229°T / "
110. " / 27°59'N,67°47'W / 600m / 10d / 4.3 cm/sec / 094°T / "
111. " / 28°04'N,68°30'W / 4190m / 10d / 1.1 cm/sec / 074°T / "
112. " / 27°55'N,68°38'W / 3890m / 22d / 0.9 cm/sec / 288°T / "

24°N (Continued)

113. MAY'73 / 27°55'N,68°38'W / 2940m / 22d / 0.9 cm/sec / 291°T / CASTON et al.,1974b
114. " / 27°58'N,68°38'W / 1610m / 23d / 1.4 cm/sec / 318°T / "
115. " / " / 615m / 7d / 8.1 cm/sec / 180°T / "
116. JUN'73 / 27°47'N,68°27'W / 610m / 23d / 1.8 cm/sec / 246°T / "
117. " / 27°45'N,68°23'W / 3650m / 9d / 3.1 cm/sec / 193°T / "
118. MAY'73 / 28°03'N,68°09'W / 1550m / 10d / 1.6 cm/sec / 017°T / "
119. " / 28°04'N,68°07'W / 2900m / 8d / 5.8 cm/sec / 110°T / "
120. " / 28°04'N,68°18'W / 760m / 8d / 2.4 cm/sec / 190°T / "
121. " / 28°01'N,68°30'W / 3790m / 17d / 1.0 cm/sec / 256°T / "
122. " / 28°05'N,68°31'W / 2960m / 15d / 1.7 cm/sec / 301°T / "
123. JUN'73 / 27°54'N,68°29'W / 2920m / 21d / 1.5 cm/sec / 294°T / "
124. " / 27°50'N,68°27'W / 1550m / 20d / 1.1 cm/sec / 253°T / "
125. " / 27°56'N,68°41'W / 3750m / 21d / 0.6 cm/sec / 228°T / "
126. " / 27°55'N,68°41'W / 2950m / 13d / 1.3 cm/sec / 223°T / "
127. " / 28°07'N,68°52'W / 1540m / 21d / 2.9 cm/sec / 326°T / "
128. " / 27°58'N,68°45'W / 3750m / 21d / 0.7 cm/sec / 251°T / "
129. " / 27°55'N,68°42'W / 2890m / 20d / 0.8 cm/sec / 191°T / "
130. " / 28°04'N,68°48'W / 1610m / 13d / 2.3 cm/sec / 311°T / "
131. " / 28°03'N,68°43'W / 530m / 7d / 9.9 cm/sec / 202°T / "
132. " / 28°01'N,68°49'W / 590m / 7d / 11.1 cm/sec / 198°T / "
133. OCT-DEC'73 / 27°44'N,69°51'W / 603.6m / 41d / 1.42 cm/sec / NORTH COMPONENT / TARBELL & BRISCOE,1976
134. " / " / 605.7m / 34d / 2.26 cm/sec / " / "

24°N (Continued)

135. OCT-DEC'73 / 27°44'N,69°51'W / 610.6m / 41d / 1.16 cm/sec / NORTH COMPONENT / TARBELL & BRISCOE,1976
136. " / " / 639.5m / 41d / 1.78 cm/sec / " / "
137. " / " / 730.6m / 35d / 1.57 cm/sec / " / "
138. " / " / 1014.4m / 28d / 0.88 cm/sec / " / "
139. " / " / 1023.1m / 11d / 0.25 cm/sec / SOUTH COMPONENT / "
140. " / " / 2050.4m / 41d / 2.88 cm/sec / " / "
141. " / " / 605.7m / 4d / 1.14 cm/sec / " / "
142. " / " / 610.6m / 41d / 1.83 cm/sec / NORTH COMPONENT / "
143. " / " / 639.5m / " / 1.87 cm/sec / " / "
144. " / " / 730.6m / 33d / 2.23 cm/sec / " / "
145. " / " / 1023.1m / 41d / 0.03 cm/sec / SOUTH COMPONENT / "
146. " / " / 2050.4m / " / 2.28 cm/sec / " / "
147. " / " / 603.6m / 34d / 2.25 cm/sec / NORTH COMPONENT / "
148. " / " / 605.7m / 24d / 0.84 cm/sec / " / "
149. " / " / 639.5m / 41d / 2.09 cm/sec / " / "
150. " / " / 730.6m / " / 1.61 cm/sec / " / "
151. " / " / 1023.1m / " / 0.44 cm/sec / SOUTH COMPONENT / "
152. " / " / 2050.4m / " / 2.49 cm/sec / " / "
153. " / 27°44'N,69°48'W / 101m / 1d / 2.35 cm/sec / " / "
154. " " / 126m / 1d / 0.55 cm/sec / NORTH COMPONENT / "

16°N

1. FEB'66 / 12°00'N,27°00'W / 4680m / 11d / 1.0 cm/sec / ESE / POCHAPSKY,1968
2. MAR'66 / " / 3800m / 11d / 2.0 cm/sec / " / "
3. MAR-JUL'70 / 16°30'N,33°30'W / 50m / 115d / 4.2 cm/sec / 292°T / KOSHLYAKOV & GRACHEV,1973
4. " / " / 300m / 115d / 2.2 cm/sec / 230°T / "
5. " " / 1000m / 115d / 0.5 cm/sec / 213°T / "

8°N

NONE

* The following data are presented separately in a modified format because they are taken from sources which do not list the year and the duration of the measurement. Data taken from NAVOCEANO Pub. 700 (1965) have been read from graphical displays.

** Current data are presented in the following format:

MONTH / POSITION / DEPTH / SPEED / DIRECTION / RELIABILITY / SOURCE

40°N

1. MAY / 41°48'N,65°00'W / 0m / 1.05 KTS / NE / FAIR / NAVOCEANO PUB. 700,1965
2. " / " / 25m / 0.57 KTS / NE / " / "
3. " / " / 200m / 0.36 KTS / SE / " / "
4. " / " / 800m / 0.27 KTS / NE / " / "
5. " / " / 1600m / 0.30 KTS / " / " / "
6. " / " / 2400m / 0.30 KTS / " / " / "
7. JUN / 39°00'N,10°48'W / 10m / 0.6 KTS / N / " / "
8. " / " / 20m / 0.62 KTS / " / " / "
9. " / " / 50m / 0.56 KTS / " / " / "
10. " / " / 100m / 0.6 KTS / " / " / "
11. " / " / 200m / 0.46 KTS / " / " / "
12. " / " / 1000m / 0.59 KTS / " / " / "

<u>36°N</u>

1. MAY / 35°54'N,5°54'W / 250m / 1.5 KTS / SW / GOOD / NAVOCEANO PUB. 700,1965
2. AUG / 35°12'N,6°42'W / 0m / 0.4 KTS / E / FAIR / "
3. " / " / 50m / 0.7 KTS / NE / " / "
4. " / " / 110m / 0.7 KTS / NNE / FAIR / "
5. " / " / 165m / 0.05 KTS / " / " / "
6. " / 36°00'N,6°42'W / 5m / 1.9 KTS / ESE / " / "
7. " / " / 110m / 0.5 KTS / SE / " / "
8. " / " / 250m / 0.7 KTS / SE / " / "

<u>32°N</u>

1. APR / 31°00'N,63°00'W / 0m / 0.3 KTS / NE / FAIR / NAVOCEANO PUB. 700,1965
2. " / " / 95m / 0.5 KTS / E / " / "
3. " / " / 190m / 0.4 KTS / E / " / "
4. " / " / 380m / 0.2 KTS / SE / FAIR / "
5. " / " / 530m / 0.1 KTS / SE / " / "
6. " / " / 900m / 0.12 KTS / NE / " / "
7. " / 30°18'N,43°48'W / 5m / 0.35 KTS / W / GOOD / "
8. " / " / 15m / 0.3 KTS / W / " / "
9. " / " / 30m / 0.3 KTS / " / " / "
10. " / " / 50m / 0.3 KTS / " / " / "
11. " / " / 100m / 0.3 KTS / W / " / "
12. " / " / 300m / 0.27 KTS / W / GOOD / "

32°N (Continued)

13. APR / 31°18'N,43°48'W / 550m / 0.17 KTS / W / GOOD / NAVOCEANO PUB. 700,1965
14. " / " / 800m / 0.2 KTS / " / " / "
15. MAY / 32°30'N,65°00'W / 0m / 1.2 KTS / NE / " / "
16. " / " / 50m / 0.5 KTS / N / " / "
17. " / " / 100m / 0.4 KTS / NW / " / "
18. " / " / 200m / 0.3 KTS / NW / " / "
19. " / " / 300m / 0.2 KTS / NW / " / "
20. " / " / 400m / 0.2 KTS / NW / " / "
21. " / " / 600m / 0.2 KTS / NW / " / "
22. " / " / 800m / 0.35 KTS / NE / " / "
23. " / " / 1000m / 0.3 KTS / SE / " / "
24. " / " / 1400m / 0.1 KTS / SE / " / "
25. " / " / 1600m / 0.1 KTS / NW / " / "
26. " / 32°00'N,65°12'W / 0m / 0.73 KTS / SE / " / "
27. " / " / 12m / 0.57 KTS / " / " / "
28. " / " / 28m / 0.50 KTS / " / " / "
29. " / " / 38m / 0.49 KTS / " / " / "
30. " / " / 48m / 0.42 KTS / " / " / "

24°N

1. APR / 26°00'N,79°48'W / 0m / 3.3 KTS / N / GOOD / NAVOCEANO PUB. 700,1965
2. " / " / 65m / 2.5 KTS / N / " / "
3. " / " / 105m / 1.2 KTS / N / " / "
4. " / " / 200m / 1.3 KTS / " / " / "
5. " / " / 325m / 0.9 KTS / NE / GOOD / "
6. MAY / 28°54'N,22°48'W / 10m / 0.65 KTS / NW / FAIR / "
7. " / " / 80m / 0.55 KTS / NW / " / "
8. " / " / 175m / 0.62 KTS / NW / " / "
9. " / " / 300m / 0.76 KTS / NW / " / "
10. NOV / 23°48'N,77°24'W / 0m / 0.76 KTS / S / " / "
11. " / " / 350m / 0.15 KTS / SE / " / "
12. DEC / 24°24'N,77°30'W / 10m / 0.58 KTS / SE / " / "
13. " / " / 120m / 0.2 KTS / E / " / "
14. " / " / 280m / 0.12 KTS / W / " / "

<u>16°N</u>

1. FEB / 16°48'N,46°18'W / 0m / 0.6 KTS / WSW / —— / BOISVERT,1967
2. " / " / 800m / 0.2 KTS / WSW / —— / "
3. FEB / 11°48'N,60°18'W / 5m / 1.4 KTS / NW / GOOD / NAVOCEANO PUB. 700,1965
4. " / " / 28m / 1.1 KTS / " / " / "
5. " / " / 52m / 0.7 KTS / " / " / "
6. " / " / 110m / 0.8 KTS / NW / GOOD / "
7. " / " / 270m / 0.9 KTS / " / " / "
8. " / 16°48'N,46°18'W / 5m / 0.57 KTS / SW / " / "
9. " / " / 15m / 0.45 KTS / " / " / "
10. " / " / 27m / 0.50 KTS / " / " / "
11. " / " / 50m / 0.41 KTS / " / " / "
12. " / " / 100m / 0.34 KTS / SW / " / "
13. " / " / 300m / 0.25 KTS / " / " / "
14. " / " / 500m / 0.20 KTS / " / " / "
15. " / " / 800m / 0.20 KTS / W / " / "
16. MAR / 13°30'N,60°48'W / 5m / 1.45 KTS / NW / " / "
17. " / " / 28m / 1.10 KTS / W / " / "
18. " / " / 52m / 1.05 KTS / W / " / "
19. " / " / 110m / 0.70 KTS / SW / " / "
20. " / " / 270m / 0.07 KTS / SW / " / "
21. APR / 14°12'N,59°42'W / 8m / 0.8 KTS / " / " / "

16°N (Continued)

22. APR / 14°12'N,59°42'W / 8m / 0.84 KTS / SW / GOOD / NAVOCEANO PUB. 700,1965
23. " / " / 50m / 0.93 KTS / SW / " / "
24. " / " / 110m / 0.84 KTS / " / " / "
25. " / " / 225m / 0.55 KTS / SE / GOOD / "
26. " / " / 375m / 0.55 KTS / SW / " / "
27. OCT / 12°48'N,47°36'W / 0m / 0.48 KTS / W / " / "
28. " / " / 25m / 0.21 KTS / S / " / "
29. " / " / 50m / 0.35 KTS / SE / " / "
30. " / " / 100m / 0.41 KTS / SW / " / "
31. " / " / 200m / 0.36 KTS / S / " / "
32. " / " / 300m / 0.35 KTS / S / " / "
33. " / " / 500m / 0.48 KTS / SE / " / "
34. " / " / 800m / 0.30 KTS / " / " / "
35. " / " / 1100m / 0.25 KTS / SE / " / "
36. " / " / 1500m / 0.22 KTS / " / " / "
37. " / " / 2800m / 0.18 KTS / N / " / "
38. DEC / 13°30'N,58°12'W / 0m / 0.36 KTS / NW / FAIR / "
39. " / " / 50m / 0.30 KTS / NW / " / "
40. " / " / 100m / " / " / " / "
41. " / " / 200m / " / " / " / "
42. " / " / 400m / " / " / " / "
43. " / " / 550m / 0.27 KTS / N / " / "

## 16°N (Continued)

44. DEC / 13°30'N,58°12'W / 600m / 0.14 KTS / N / FAIR / NAVOCEANO PUB. 700,1965
45. " / " / 800m / 0.12 KTS / " / " / "
46. " / " / 1200m / " / " / " / "
47. " / " / 1600m / " / SW / FAIR / "
48. " / " / 2000m / " / " / " / "
49. " / " / 2400m / 0.20 KTS / SW / " / "
50. " / " / 2600m / " / " / " / "

## 8°N

NONE

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